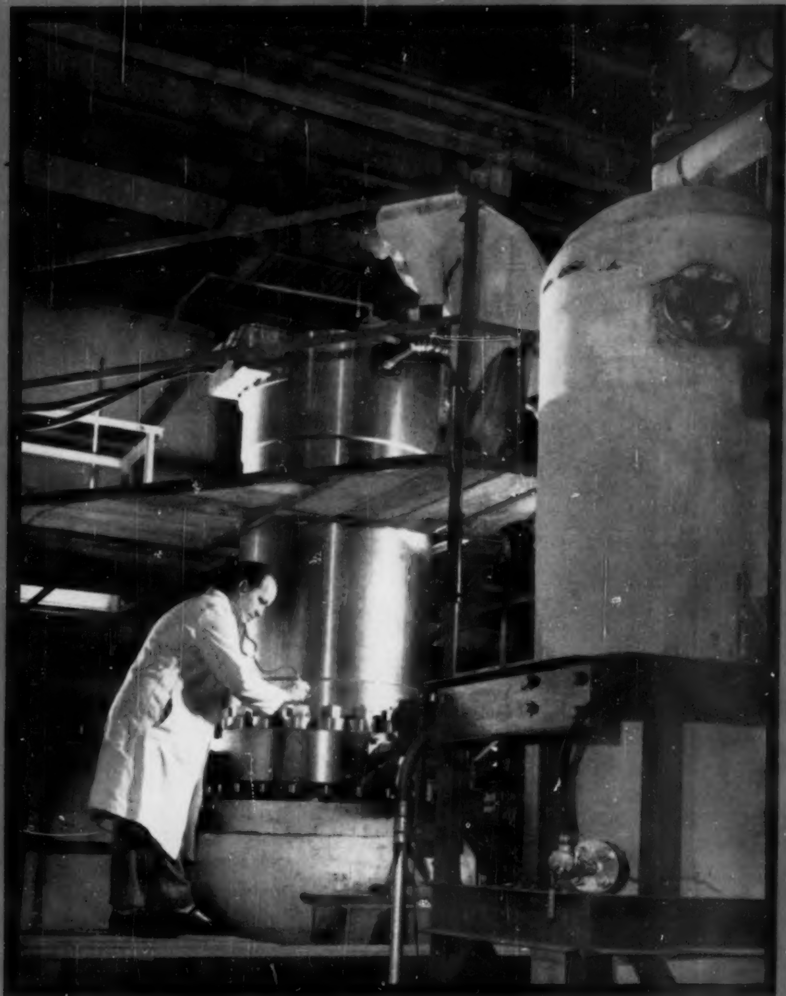
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

July 1956



Tests underway on canned pump design at Westinghouse Elec. Corp.

Air-Heater Corrosion

Problems of Locating Power Sites

A Way to Simplify Power Plants

Ion Exchange History

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 28 **No. 1**

July 1956

Feature Articles

Editorials

Departments

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BPA

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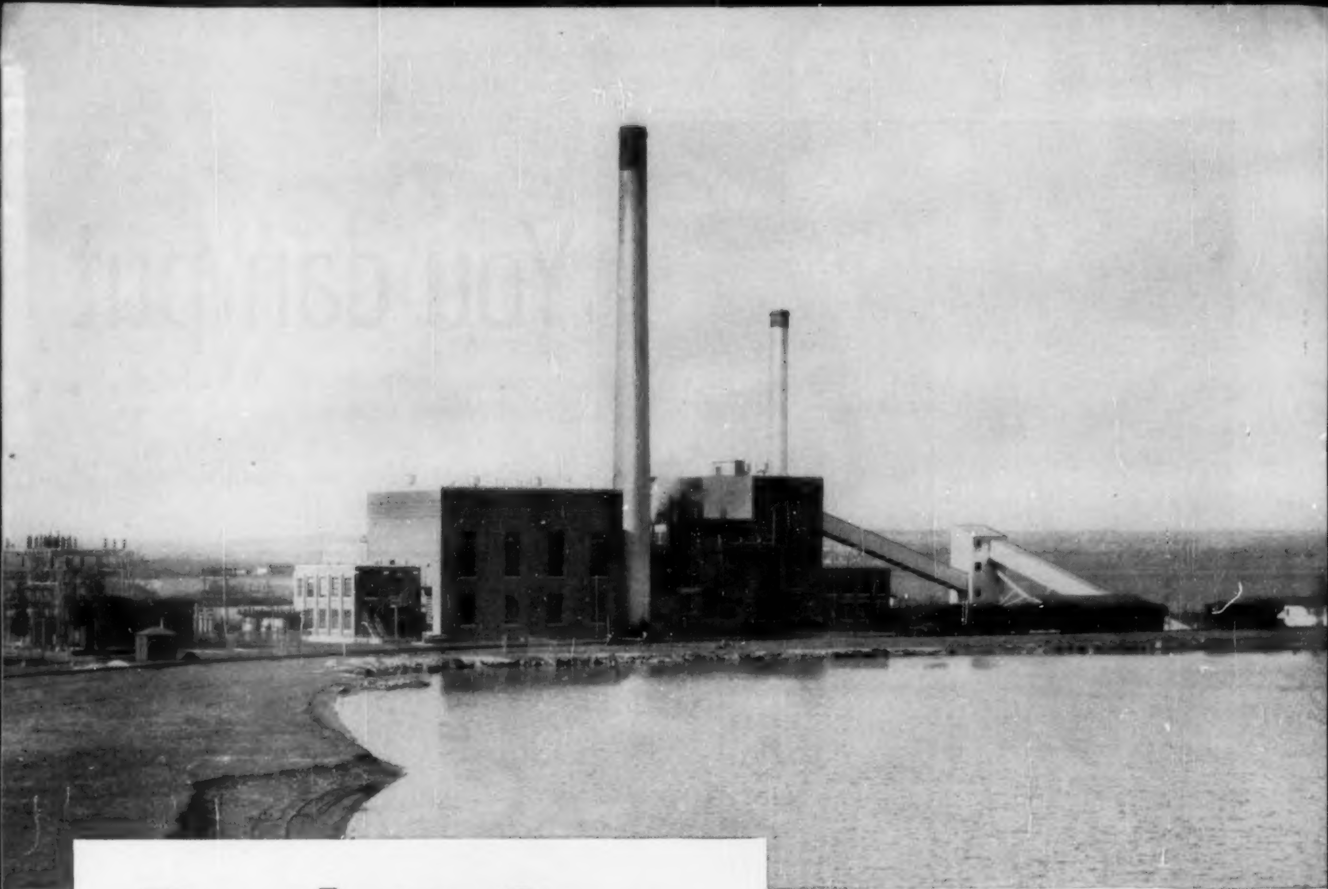
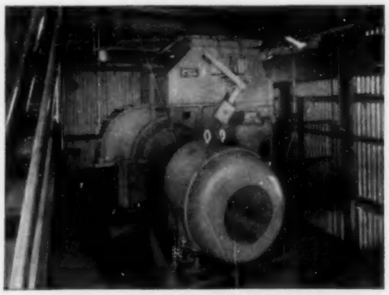


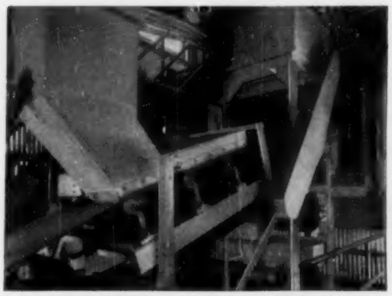
General View of Bay Front Steam Plant
Lake Superior District Power Co.
Sargent and Lundy
Consulting Engineers

Bartlett-Snow coal handling at Ashland

● The illustration above shows the first 38,600 KW unit of a plant which is to be extended into a 60,200 KW station. Coal is received by lake boat at a near-by deep water dock, and carried to the plant in railroad cars. All handling facilities including the track hopper and grillage, duplex feeder, conveyors, gallery, chutes, tripper and all supporting structures, were fabricated in our shops and installed by our erectors to Sargent and Lundy specifications. For maximum efficiency and fixed unit responsibility, let the Bartlett-Snow coal handling engineers work with you on your next job



150 Ton Per Hour Ring Roll Crusher
Showing By-Pass Gate and Drive

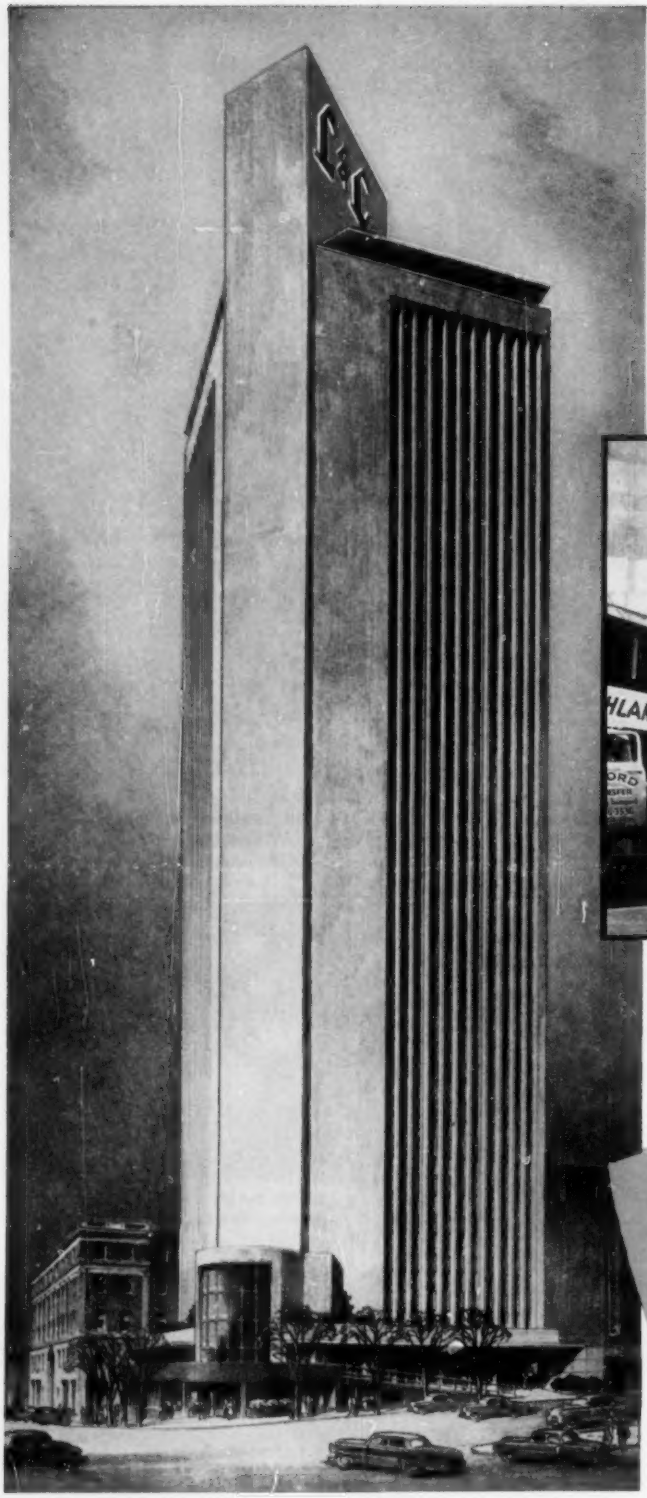


Belt Conveyor Showing Automatic
Weightometer and Vertical Take-up

DESIGNERS · ENGINEERS · FABRICATORS · ERECTORS

BARTLETT-SNOW
CLEVELAND 5, OHIO

"Builders of Equipment for People You Know"

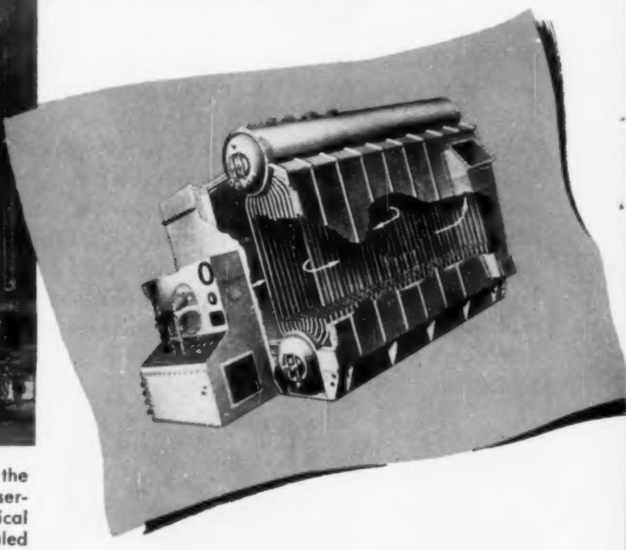


Life and Casualty Tower will be the tallest commercial structure in the southeastern United States. It contains 30 floors plus basement, observation platform and a three-story penthouse containing the mechanical equipment — including two VP package boilers. The building is scheduled for occupancy in January, 1957. It is owned by Life and Casualty Insurance Company of Tennessee.

You can put

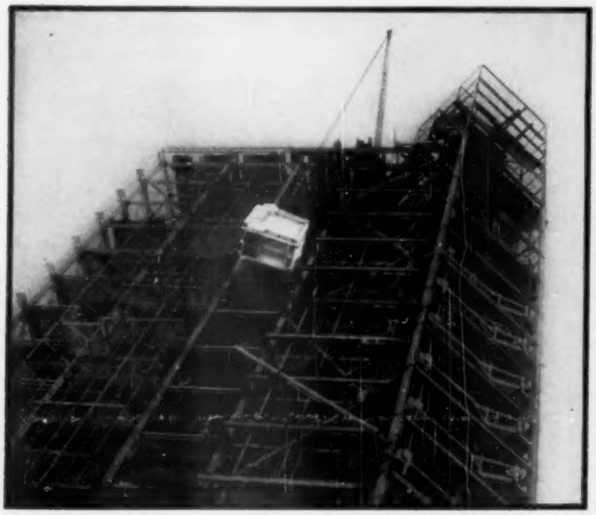
. . . . .

Take It Away — First of two VP Boilers — 27,000 pounds — clears the truck bed in the first step of its 32-story journey. VP Boilers come fully assembled, ready for water, rail or road shipment anywhere in the world.



a VP boiler ANYWHERE!

anywhere the floor-loading's adequate, of course. In Nashville's nearly-finished Life and Casualty Tower, two Combustion Engineering Package Boilers, Type VP, were installed in a 32nd-floor penthouse — nearly 400 feet above the street. The pictures show how the job was done.



Almost Home — This VP has probably shattered the altitude record for boilers now — and it has another 30 or 40 feet yet to go. That's one of the advantages of the VP. You pick the spot and the rigging boys will find a way to move it in.

Boiler in a Penthouse — Now it's almost settled in its permanent skytop home; about set to bring up number 2. When the floor is ready, they'll hook up fuel, water and the job's done. They'll burn gas in these boilers, with oil as stand-by.

The completely shop-assembled VP Boiler, shown at left, is available in fourteen sizes from 4,000 to 40,000 lb steam per hr . . . for operating pressures up to 500 psi . . . for pressure firing of liquid or gaseous fuels. The VP Boiler has more water-cooled area per cubic foot of furnace volume than any other boiler of its size and type. The larger lower drum — 30-inch diameter — permits a simple, symmetrical tube arrangement . . . greater water storage capacity . . . easy access for washing down or inspection. A low speed centrifugal fan which is exceptionally quiet in operation is standard equipment. The simple baffle arrangement results in low draft loss . . . simple soot blowing . . . no dead pockets . . . high heat absorption. The VP is enclosed in a reinforced, gas-tight, welded steel casing, and shipped completely assembled with firing equipment, fittings and forced draft fan. For foundation, the VP Boiler requires only a simple concrete slab.

COMBUSTION ENGINEERING

C·E

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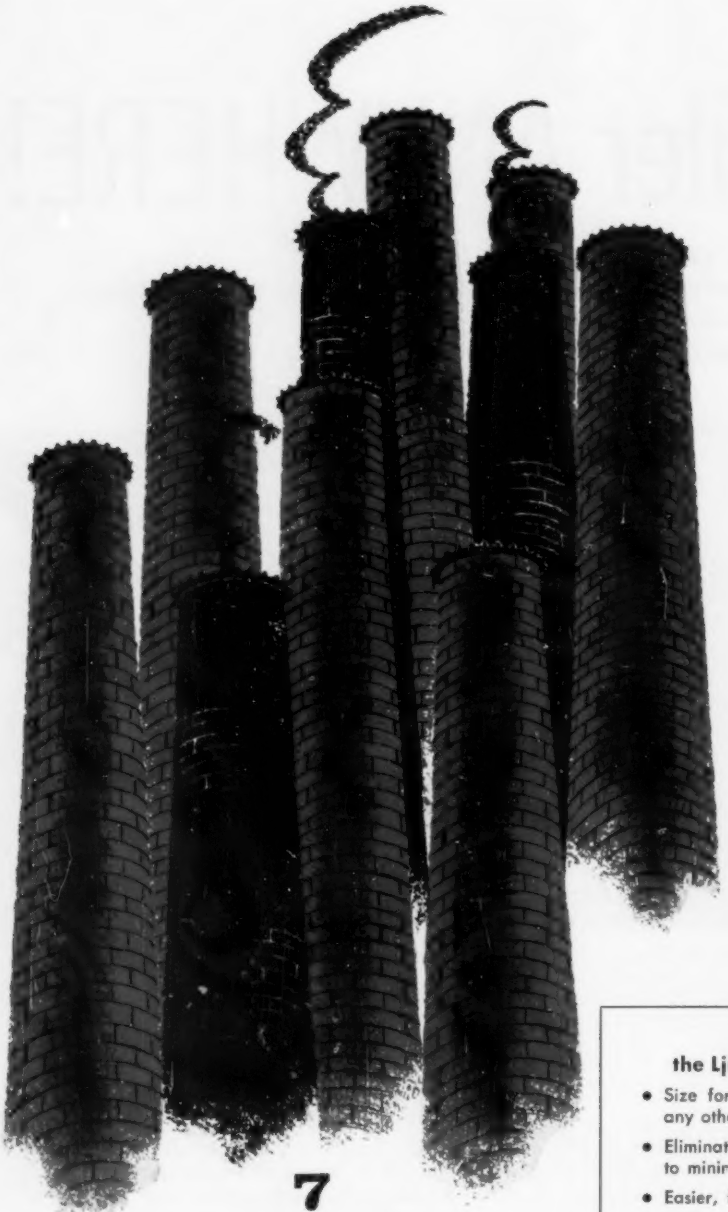
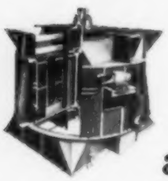
Canada: Combustion Engineering-Superheater Ltd.

B-928

Steam Generating Units • Nuclear Reactors • Paper Mill Equipment • Pulverizers • Flash Drying Systems • Pressure Vessels • Home Heating and Cooling Units • Domestic Water Heaters • Soil Pipe



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62,000 coal cars, with 8,000 more on order, insure dependable deliveries from mines on the C&O
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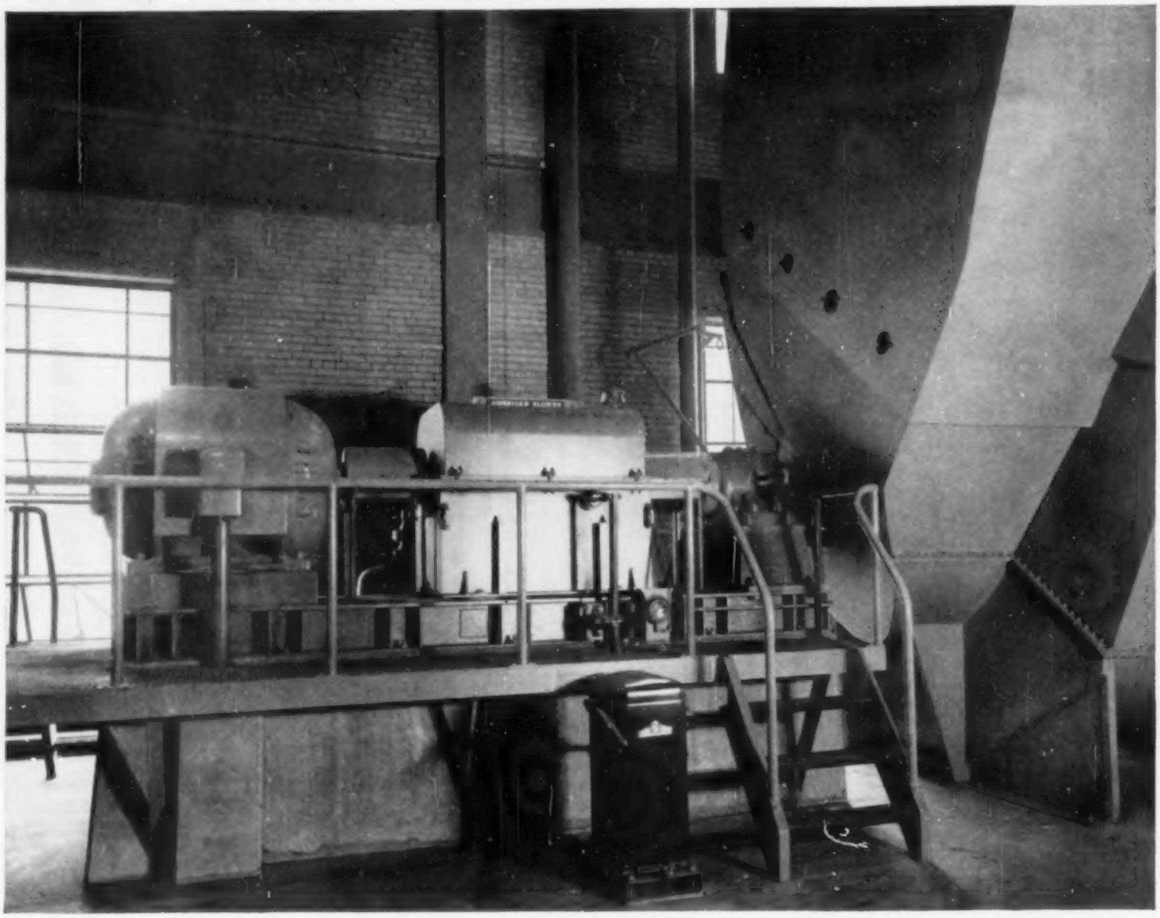
WORLD'S LARGEST CARRIER OF BITUMINOUS COAL
For dependable deliveries of top quality coals, contact coal producers on the C&O. And if you need help in meeting your own particular fuel requirements, write to: R. C. Riedinger, General Coal Traffic Manager, Chesapeake & Ohio Railway Company, Terminal Tower, Cleveland 1, Ohio.

SAVE POWER, REDUCE PRESSURE, PROLONG



ON MECHANICAL DRAFT FANS

Accurate and efficient control of mechanical draft is vital in modern power-plant operation. Gýrol Fluid Drive is the answer for all the control requirements of this important job.

To begin with, Gýrol Fluid Drive transmits power through a vortex of oil, providing infinitely adjustable speed control to keep the fan always operating at its optimum design or selection point.

. . . This saves horsepower, gives good stable volume and pressure control over the operating range.

. . . This simplifies motor-starting equipment, and in many cases simplifies basic motor design for the mechanical-draft application.

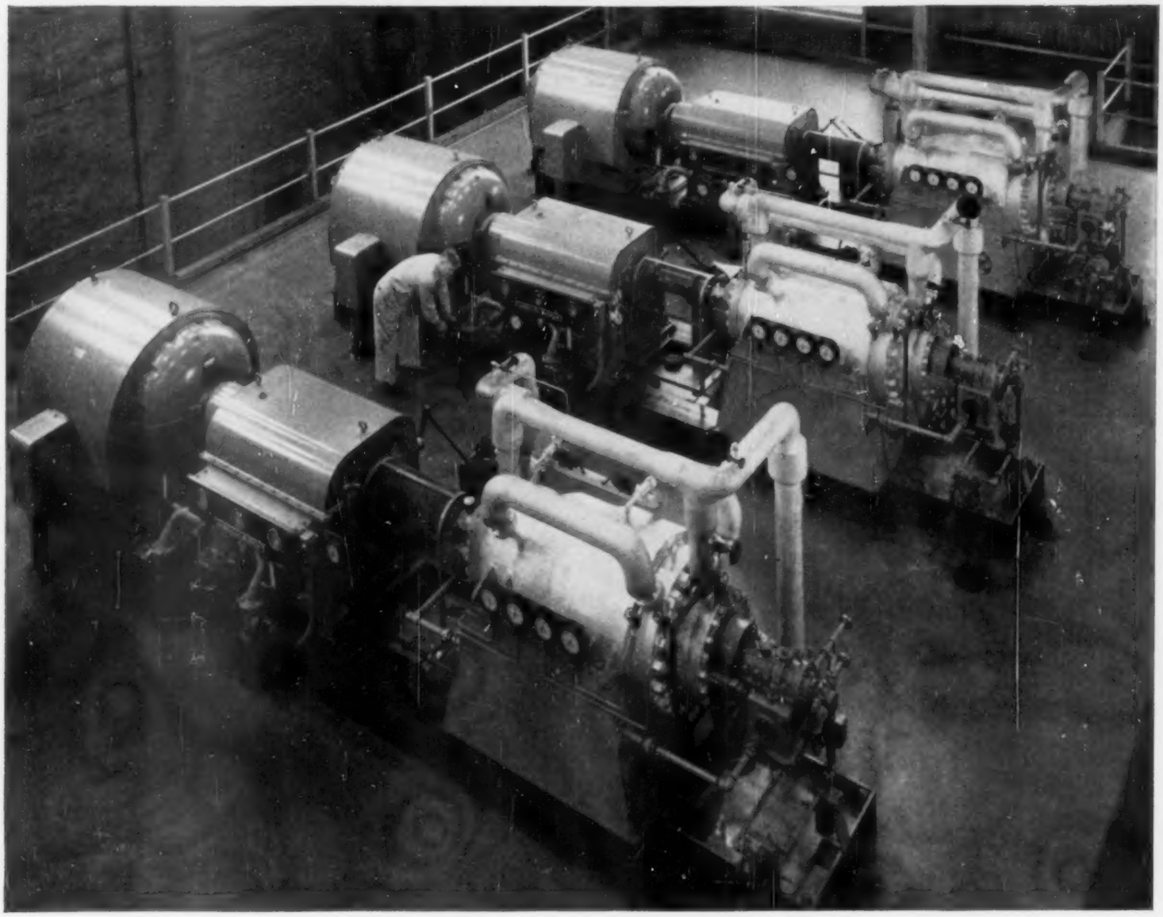
. . . This reduces damaging high- and long-duration inrush currents on the motors; eliminates starting shocks; provides no-load starting of high WR^2s that assist in the new, high-volume, high-pressure fan wheels.

. . . This prolongs life of fan bearings, and reduces fly-ash abrasion on fan wheel, fan scroll, inlet boxes, and breeching connections.

Add to these advantages the reduction in noise level — not only a boon to operating personnel, but of especial importance in outdoor plants — and you have a total of power-saving, cost-saving benefits which are overwhelmingly in favor of Gýrol Fluid Drive for your next power-plant expansion.

Rugged constant-speed induction motor + American Blower Gýrol Fluid Drive = Smooth, adjustable-speed control

EQUIPMENT LIFE WITH GÝROL FLUID DRIVES



ON BOILER FEED PUMPS

Of all power-plant auxiliaries, the boiler feed pump consumes the greatest single segment of invested power. To release more of this power to consumer lines, more and more power plants of all sizes are turning to Gýrol Fluid Drive for pump control.

For one thing, Fluid Drive saves power over the entire operating range by eliminating wasteful throttling by valves.

Secondly, on modern high-pressure boiler installations, Fluid Drive permits reduction in pressure, because of its adjustable-speed feature—resulting in further power savings.

And Fluid Drive reduces wear on bearings and other vital pump parts by letting the pump operate at speeds that fit boiler demands.

In addition, paralleling of pumps is simplified. And change-over from operating to standby pump is quick and easy—for there's no need for boiler shutdown.

Weigh these facts thoroughly when your expansion program reaches the planning stage. Better yet, talk them over with an American Blower engineer. His knowledge of the application of Gýrol Fluid Drives in modern power plants can prove valuable to you. Call our nearest branch, or write: American Blower Corporation, Detroit 32, Michigan. In Canada: Canadian Sirocco Company, Ltd., Windsor, Ontario.

AMERICAN BLOWER

Division of AMERICAN-Standard

J. R. P.
Here is an inexpensive, rugged forged steel valve that is quality-controlled to meet the highest standards
E. B. J.

ROCKWELL BUILT
Edward Valves

Large size knobbed handwheel eases operation.

Deep, full-size stuffing box and Evalpack packing combine to minimize maintenance.

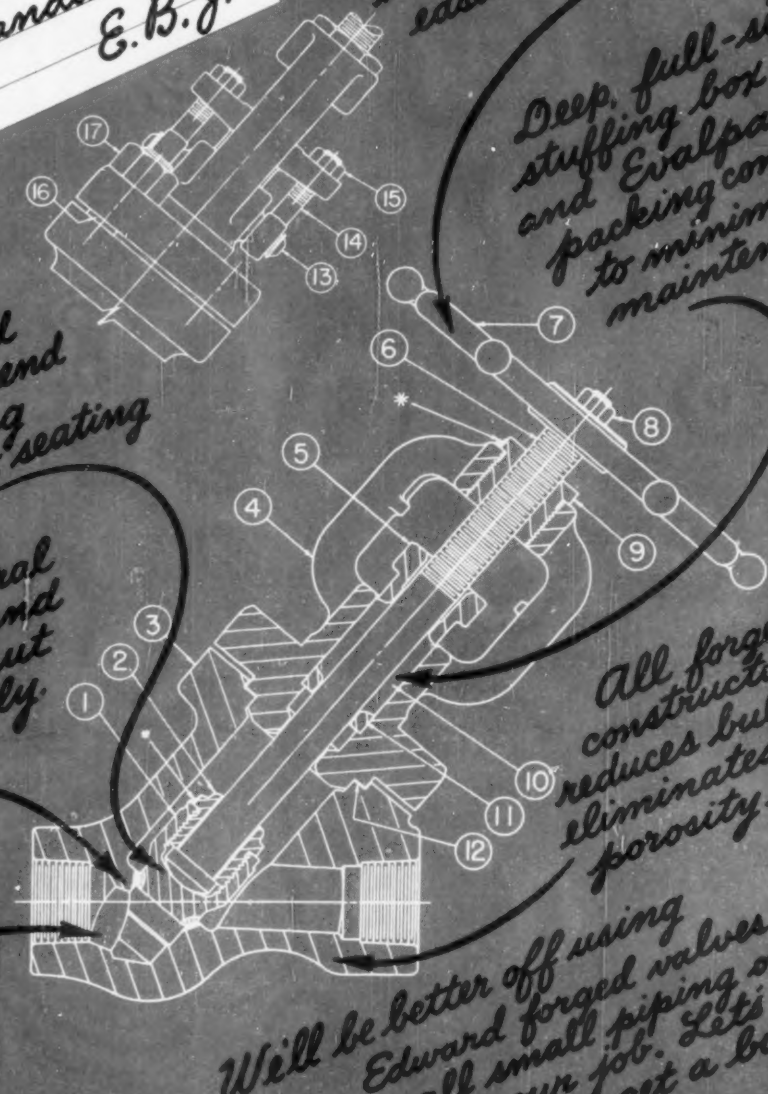
Swivel disk and radiused stem end prevent galling insure perfect seating

Edward integral Stellited seat and Stellited disk cut repairs sharply.

All forged construction reduces bulk—eliminates porosity.

Straight through flow minimizes turbulance and pressure drop.

We'll be better off using Edward forged valves for all small piping on our job. Lets get a bid.



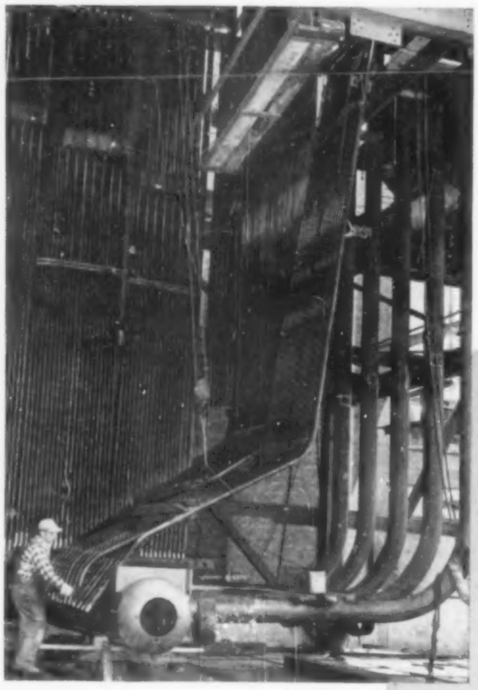
LIST OF MATERIAL QUANTITIES ARE FOR 1 GLOBE OR 1 ANGLE VALVE WHERE A.S.T.M. SPECIFICATIONS ARE INDICATED THE LATEST REVISION APPLIES					
PIECE NO.	NAME OF PIECE	NO. REQ'D	MATERIAL	SPECIFICATIONS	EDWARD MS NO.
1	DISK	1	FORGED ALLOY	A.S.T.M. A182 GRADE F11	227
			STEEL STELLITED		483
2	DISK NUT	1	STEEL	A.I.S.I. C1120	:23
3	BODY	1	FORGED STEEL (a)	A.S.T.M. A105, GRADE II	111/483
			FORGED STEEL (b)	A.S.T.M. A182, GRADE F11	227/483
4	BONNET	1	FORGED STEEL (a)	A.S.T.M. A105, GRADE II	111
			FORGED STEEL (b)	A.S.T.M. A182, GRADE F11	227
5	GLAND	1	MALLEABLE IRON	A.S.T.M. A220, GRADE 53004	324
6	STEM	1	EVALLOY	A.I.S.I. GRADE 416	261
7	HANDWHEEL	1	MALLEABLE IRON	A.S.T.M. A47 GRADE 32510	322
8	STEM NUT	1	STEEL	A.S.T.M. A194 - GRADE 1	124
9	YOKE BUSHING	1	BRONZE	A.S.T.M. B62	412
10	PACKING RINGS		EVALPAK	HIGH TEMPERATURE PACKING	501
11	JUNK RING	1	STEEL - EVALIZED	A.I.S.I. C1120	123
12	BONNET GASKET	1	IRONKOTE		505
13	GLAND BOLT WASHER	2	STEEL		
14	GLAND BOLT	2	FORGED STEEL EVALIZED	A.S.T.M. A105, GRADE II	111
15	GLAND BOLT NUT	2	STEEL-EVALIZED	A.S.T.M. A194 - GRADE 0	125
16	TAP END STUD	4	ALLOY STEEL (c)	A.S.T.M. A193	
17	BONNET STUD NUT	4	STEEL (c)	A.S.T.M. A194 -	

EDWARD VALVES, INC.
SUBSIDIARY OF ROCKWELL MANUFACTURING CO.
EAST CHICAGO, INDIANA

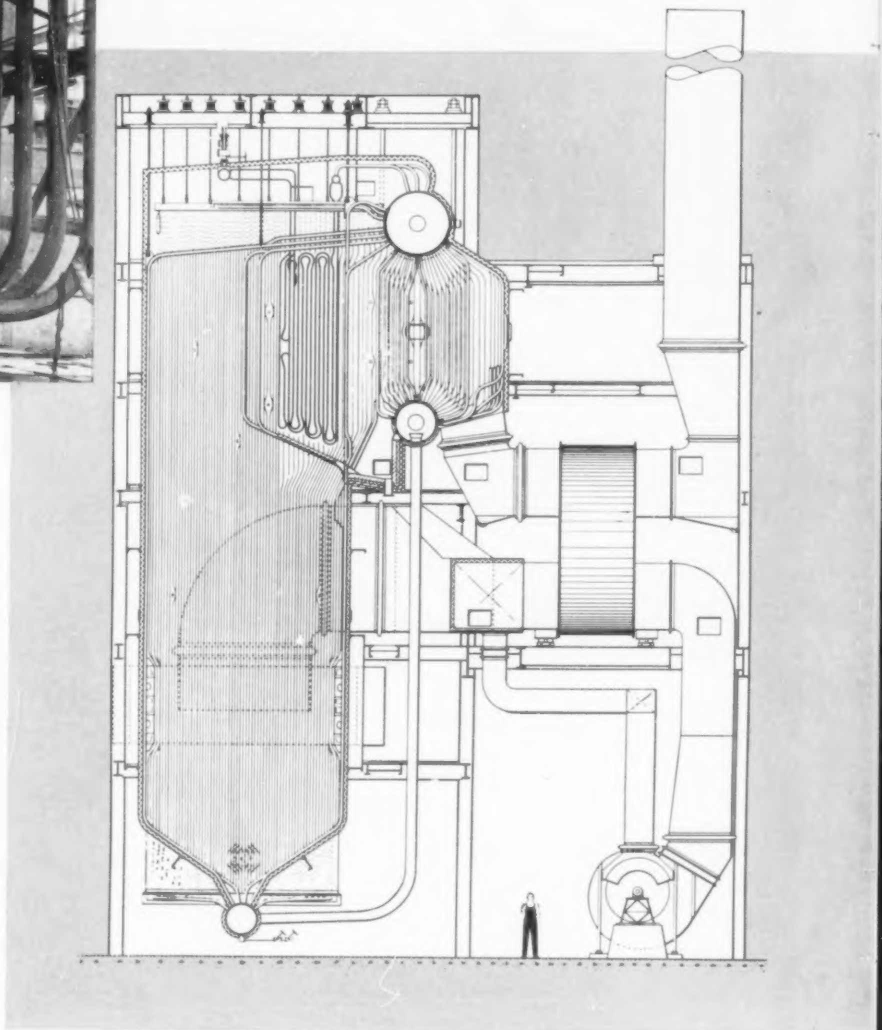
FORGED STEEL
GLOBE AND ANGLE VALVES

DRAWN		DRAWING NO
CHK'D		AE-3529-2
APP'D	DATE	

Edward builds Globe and Angle Stop, Non-Return, Check, Stop-Check, Gate, Blow-Off, Mudline, Relief, Hydraulic, Instrument, Gage, and Special Valves and Strainers.



More Kilowatt with REPUBLIC



SPECIFICATIONS

CAPACITY
350,000 lbs. of steam per hour

DESIGN PRESSURE
450 psi

OPERATING PRESSURE
400 psi

STEAM TEMPERATURE
700°F.

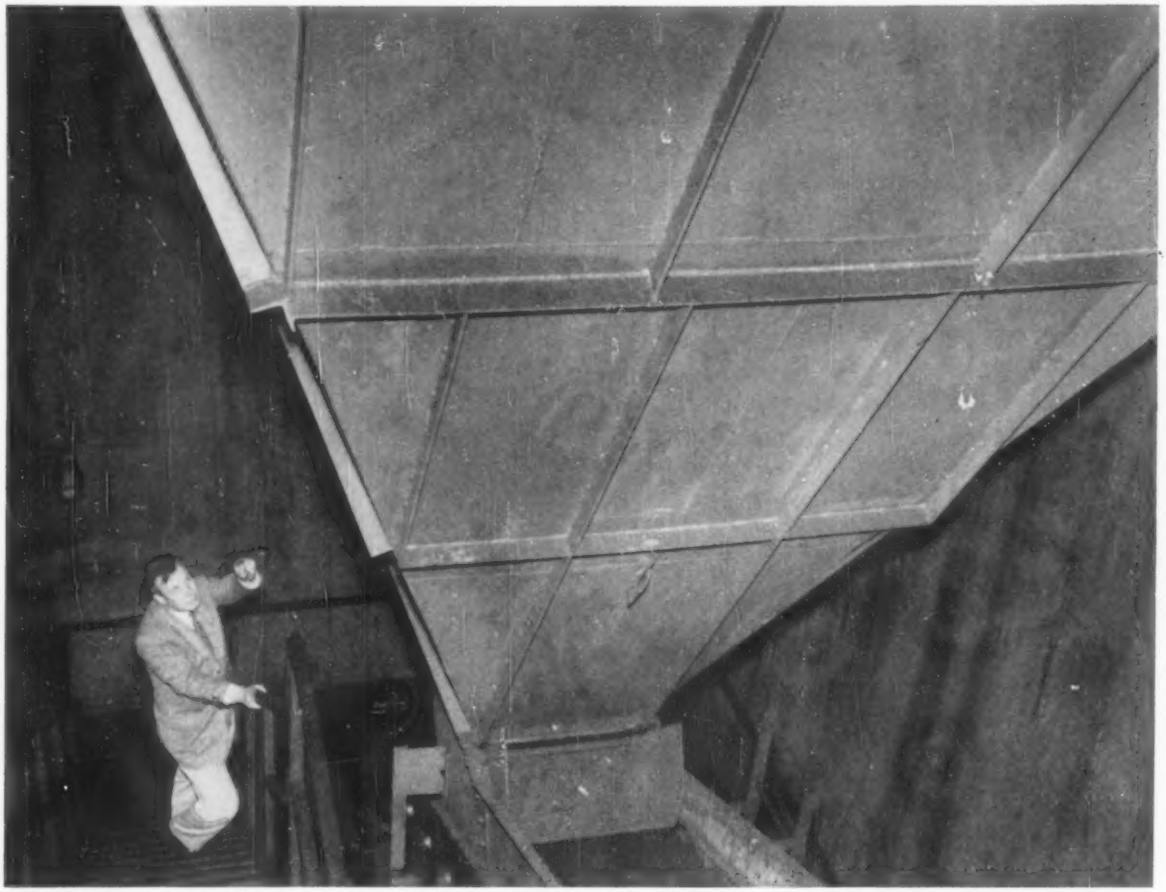
HEATING SURFACE (Boiler)
12,550 sq. ft.

HEATING SURFACE (Water Walls)
7,530 sq. ft.

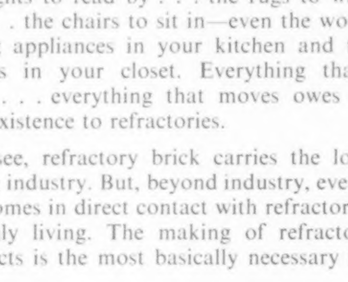
REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels



Still another installation of Lukens 20% Type 304 stainless-clad steel coal handling equipment . . . this time at Picatinny Arsenal, Dover, N. J.



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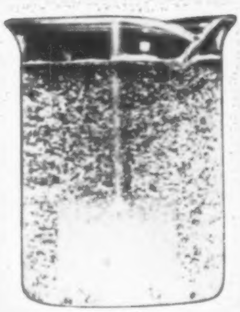
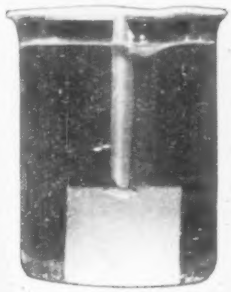
A New, Better Coagulant

NALCO 600

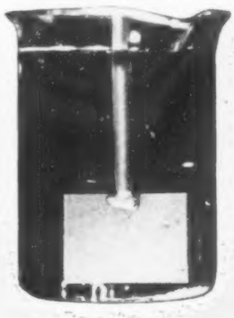
POLYELECTROLYTE



Alum



Alum plus
typical polyelectrolyte



Alum plus
Nalco 600

● As a coagulant in water clarification, and under many process coagulation conditions, new and different Nalco 600 has shown such great promise, both in performance and economy characteristics, that it has now been made available for general use as an established member of the Nalco family of chemical aids to industry.

Extremely difficult coagulation conditions provide especially economical applications for Nalco 600. It can be used alone or in conjunction with other coagulants. A very low dosage of Nalco 600 usually permits as much as 50% reduction in dosage of alum, activated silica, iron sulfate or clay type treatments . . . and results in a cleaner, clearer supernatant liquid.

Nalco 600 was invented in the Nalco Laboratories, and is being manufactured *only* by Nalco. For complete data on Nalco 600, and expert technical assistance to solve your clarification and coagulation problems, call Nalco now.

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LOWER STOCKPILING COSTS

with versatile "EUC" Twin-Power Scraper

Loaded from river barges, the "Eucs" haul coal for immediate plant use and for stockpile storage.

Euclid "Twin" dumps its big load fast into drive-over hopper that supplies the plant.

A Midwest power company has added two of these overhung engine "Twins" to their fleet of other Euclid Scrapers. These new Model TS-18 "Eucs" provide even greater efficiency in coal reclaiming and stockpiling.

Public utilities and industrial plants have found the Euclid 4-wheel drive Twin-Power Scraper a real cost-cutter in coal stockpiling. The Twin-Power principle, pioneered by Euclid, enables this unit to load itself in loose or compacted coal. Movement of the standard 27.00 x 33 or optional 33.5 x 33 tires over the pile increases compaction 10 to 15 lbs. per cu. ft., eliminating spontaneous combustion problems.

The new overhung engine TS-18 provides even more maneuverability and economy than earlier Euclid "Twins" that had proved their advantage over other stockpiling equipment. It has two 218 h.p. engines, each driving a separate axle through a Torqmatic Drive. For jobs requiring even greater power, the tractor is available with a 300 h.p. engine. This new "Twin" can carry a 23-ton load at speeds up to 26 mph. With its exceptional maneuverability and ease of operation it works in close quarters extending, raising, and relocating stockpiles.

To get a production and cost estimate for your coal handling problems, call the Euclid dealer near you. He can show you why *Euclids are your best investment.*

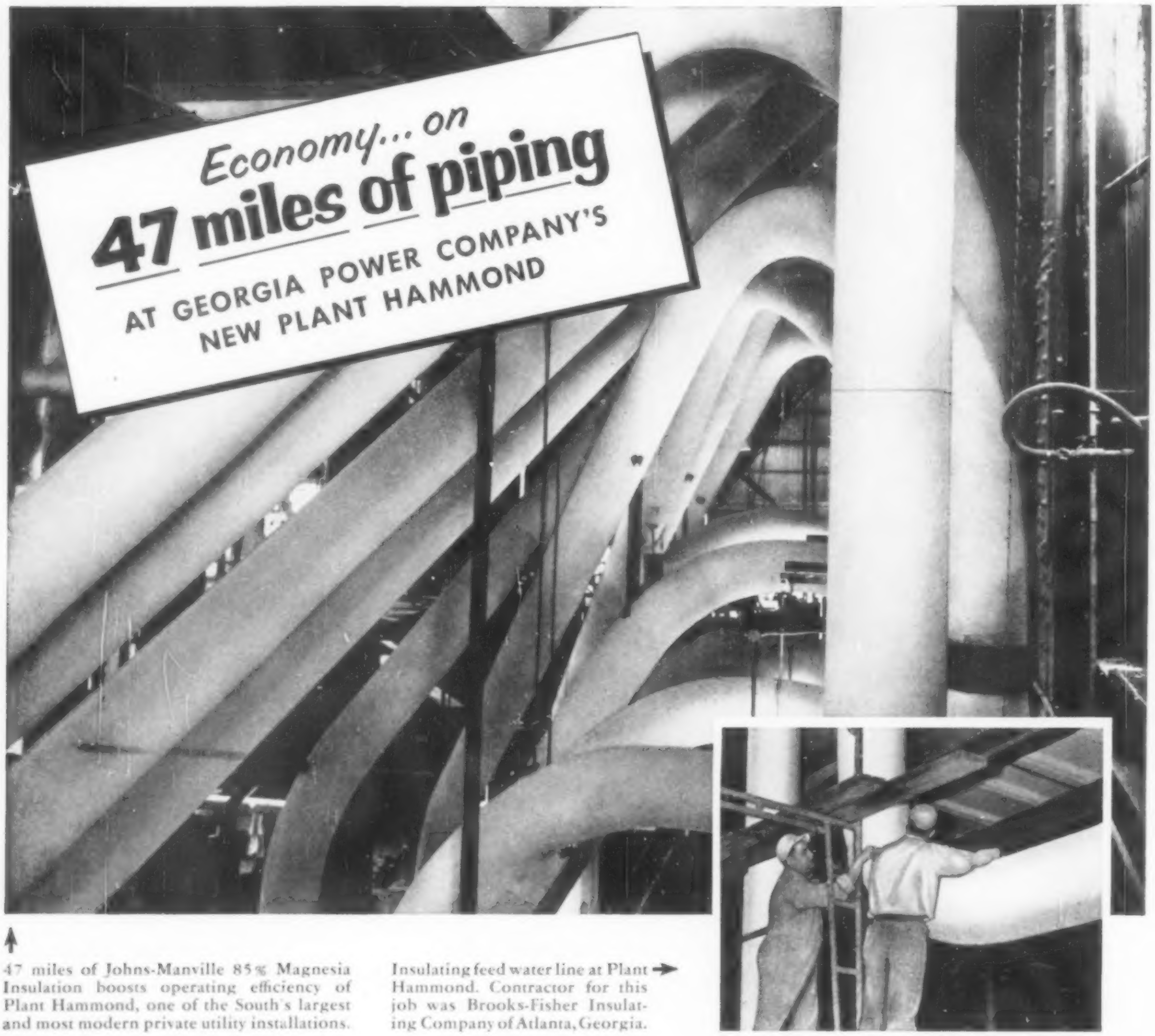
EUCLID DIVISION, GENERAL MOTORS CORPORATION, Cleveland 17, Ohio

EUCLID

Euclid Equipment

GM GENERAL MOTORS MORE POWER FOR YOU

FOR MOVING EARTH, ROCK, COAL AND ORE



↑ 47 miles of Johns-Manville 85% Magnesia Insulation boosts operating efficiency of Plant Hammond, one of the South's largest and most modern private utility installations.

Insulating feed water line at Plant Hammond. Contractor for this job was Brooks-Fisher Insulating Company of Atlanta, Georgia. →

J-M 85% Magnesia Insulation helps cut fuel rate 25% below national average

Officials of the Georgia Power Company were gratified when the coal rate of their new Plant Hammond worked out at 0.75 lb. per KW HR, 25% below the national average. In their annual *Electrical Industry Statistics, Electrical World* had reported that increased efficiency in the techniques of power production has lowered the average coal rate to 1 lb. per KW HR. in 1954.

An important factor contributing to Plant Hammond's high efficiency was the selection of insulation. Johns-Manville's 85% Magnesia was applied in the most economical thicknesses throughout the plant for all piping and equipment operating in its temperature range. At higher temperatures 85% Magnesia was used in combination with J-M Superex® diatomaceous silica insulation.

This is only one of thousands of case histories where J-M 85% Magnesia has helped industry achieve outstanding fuel savings and increased operating efficiency. In all types of manufacturing and processing plants it is the standard for temperatures to 600F . . . providing high insulating value, easy application, long life, initial low cost and minimum maintenance. Write today for further information on J-M 85% Magnesia and Johns-Manville's complete drawing-board-to-job-site insulation service. Address Johns-Manville, Box 60, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

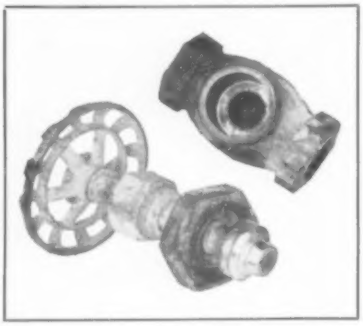
Johns-Manville *first in* INSULATION

MATERIALS · ENGINEERING · APPLICATION

"I got 5 years of service from a valve I expected to last only 90 days"

Mr. C. L. Worthington, Chief Engineer for E. L. Bruce Co., Little Rock, Arkansas plant, standing near a Walworth No. 225P Bronze Globe Valve with "500 Brinell" stainless steel seats and discs that was installed in severe boiler blowdown service. Hardened seats and discs are especially resistant to wire drawing, steam cutting, or galling.

Some time ago Mr. C. L. Worthington, Chief Engineer for E. L. Bruce Co. plant at Little Rock, Arkansas, was having valve trouble on some newly installed boilers. The first boiler to go in service generated 600 hp operating at 200-pounds pressure. The water was so bad that a hot lime and soda ash water softener treatment had to be used, and it was necessary to add other chemicals to this solution from time to time. Mr. Worthington wanted to use a continuous blowdown to skim off the worst part of the scum on the water. He installed a small blow pipe about an inch below the normal water level in the boiler. This worked well, except that the one-inch valve on the line could only be partially opened and let a small part of the scum be blown off at one time. If the valve was widely opened, it would not take long to lower the water level in the boiler and run the steam pressure down. This service gave Mr. Worthington lots of valve trouble, as can well be imagined, because of the extreme wire drawing that occurred.



A Walworth No. 225P Bronze Globe Valve that gave perfect performance for four years and 362 days in a severe boiler blowdown service where the Chief Engineer said he had never been able to keep a valve more than 60 to 90 days.

One day the Walworth representatives in that area, called upon Mr. Worthington and demonstrated the outstanding features of the Walworth No. 225P Bronze Globe Valve. This valve, which has a working steam pressure rating of 350-pounds at 550°F, has a plug-type stainless seat and disc which has been heat treated to a minimum hardness of 500 Brinell. After listening to the Walworth men and examining a 225P valve, Mr. Worthington agreed that he would try one in the severe service described. He said if it lasted 90 days, he would consider that it had done a good job.

The valve went into service and came out within three days of being in service five years under very severe operating conditions. The valve was used 24 hours a day from early in the morning on Monday until Saturday night, when it was closed until the following Monday morning. It was never opened more than three-quarters of a turn, and most of the time it was opened only one-half to one-quarter of a turn. For the life of the valve, nearly five years, it never failed to give a 100% closure when shut on Saturday night until opened Monday morning.

When another 600 hp 200-pound pressure boiler went into service, it also was equipped with a one-inch Walworth No. 225P Bronze Globe Valve on the same service.

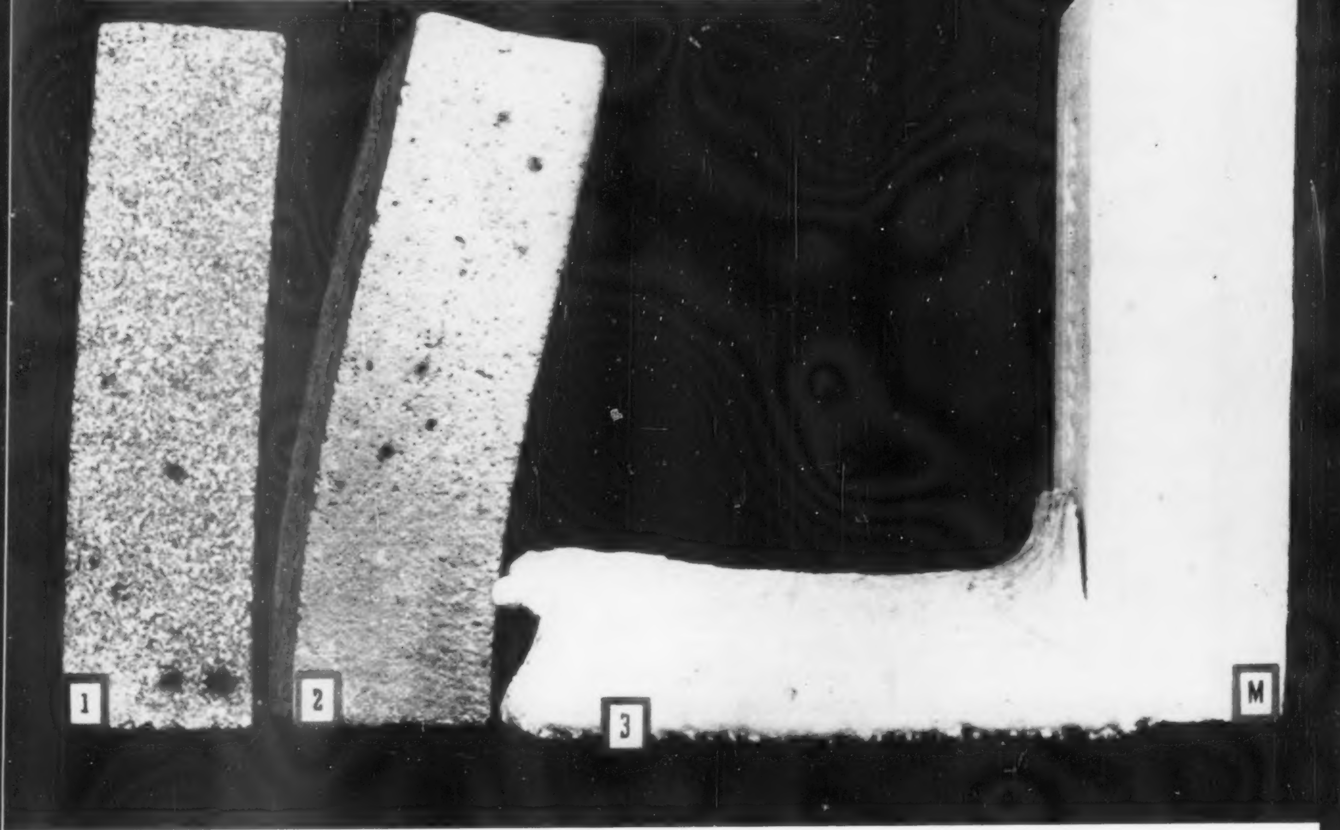
In view of the severe service and the wire drawing to which this valve was subjected, it is interesting to note that the original valve (which was taken out of service almost five years after it had been installed) was removed – not because the seat and disc were wire drawn – but because the turbulence of the steam had finally caused a small hole to occur in the wall of the body of the valve. Needless to say, the valve that was taken out of service was replaced immediately by another one-inch Walworth No. 225P Bronze Globe Valve, positive assurance that Mr. Worthington is satisfied that this valve has "done a good job."

Other Walworth products include complete lines of Gate, Globe, Angle, Check and Lubricated Plug Valves in bronze, iron, steel, stainless steel and special alloys. Complete information and literature will be furnished upon request.

WALWORTH

60 East 42nd Street, New York 17, New York

SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. CONOFLOW CORPORATION M & H VALVE & FITTINGS CO. SOUTHWEST FABRICATING & WELDING CO., INC. WALWORTH COMPANY OF CANADA, LTD.



Held at 3000°F for five hours, these four brick, commonly recommended to resist high temperatures, show varying effects. Samples 1, 2, and 3 softened and slumped to different degrees, indicating loss of usefulness even below this temperature. Sample 4, a Mullfrax® electric furnace mullite refractory, is unaffected by the heat.

fourth in a series . . . **HEAT RESISTANCE**

Unusual Properties of Refractory Materials

Heat Resistance—Exposed only to heat, Carborundum's Super Refractories can actually be used with complete safety at temperatures above 3000°F. Long before such temperatures are approached, even high heat duty and super-duty firebrick lose much of their usefulness. That's because they begin to soften several hundred degrees below their theoretical safe limits. Not so Carborundum's Super Refractories. Their strength and rigidity are maintained close to their theoretical limits.

In practice, of course, you must contend with many more conditions than heat alone. Corrosion, thermal shock, load, abrasion, erosion, etc., are usually combined with temperature. This combination of conditions may tend to lower heat resistance of refractories. That's why a refractory cannot be selected solely on its ability to withstand temperature. It also explains the reason Carborundum offers so many specialized refractories.

Heat resistance is thoroughly explored in the forthcoming issue of Carborundum's new magazine "Refractories." Send for your copy today.

CARBORUNDUM

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VALUABLE INFORMATION FOR USERS OF:

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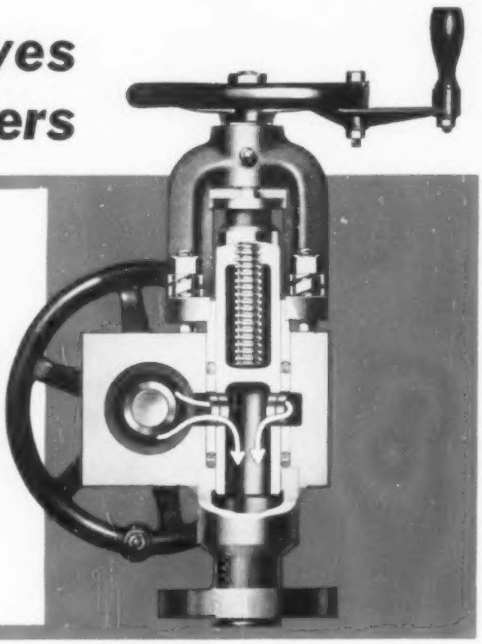

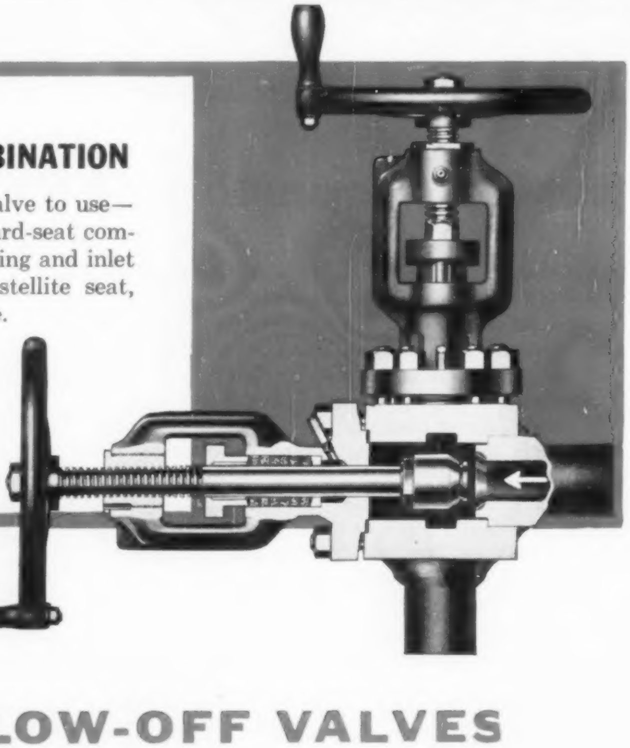

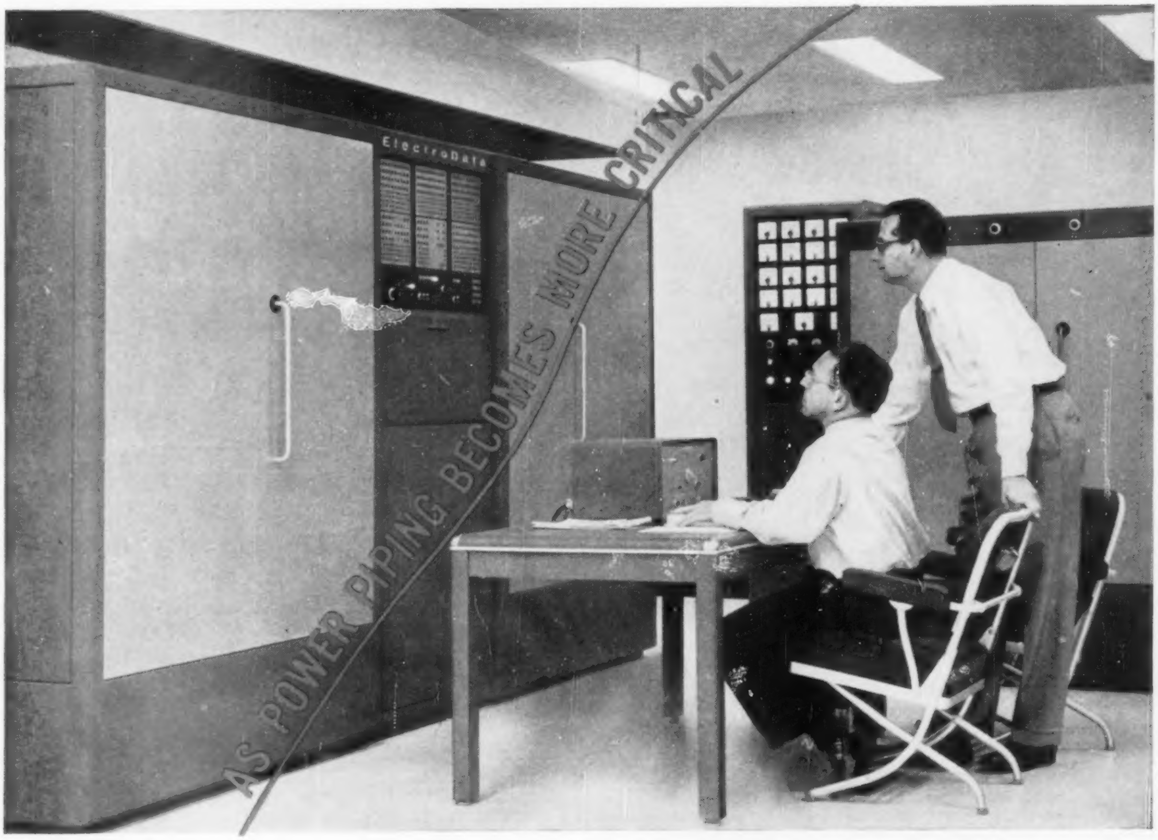

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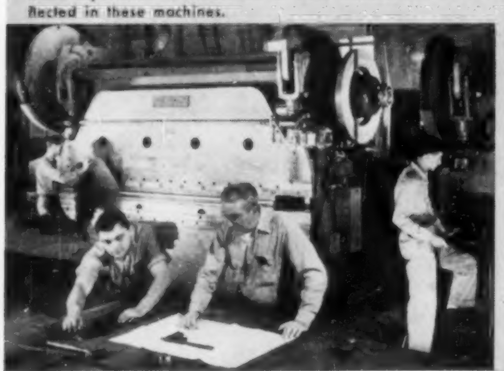

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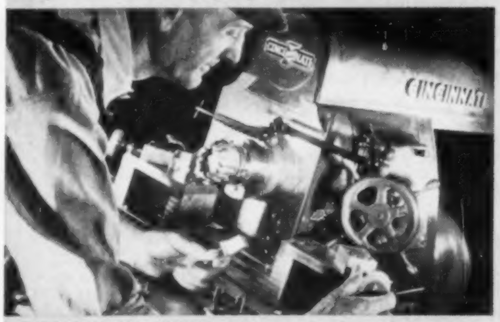

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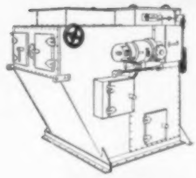

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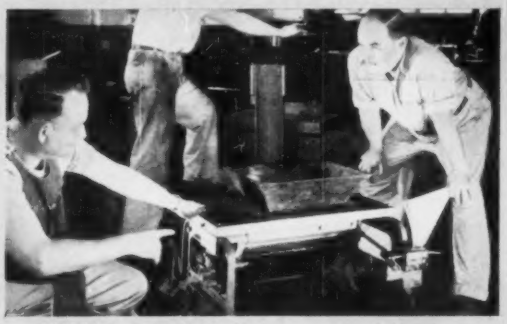

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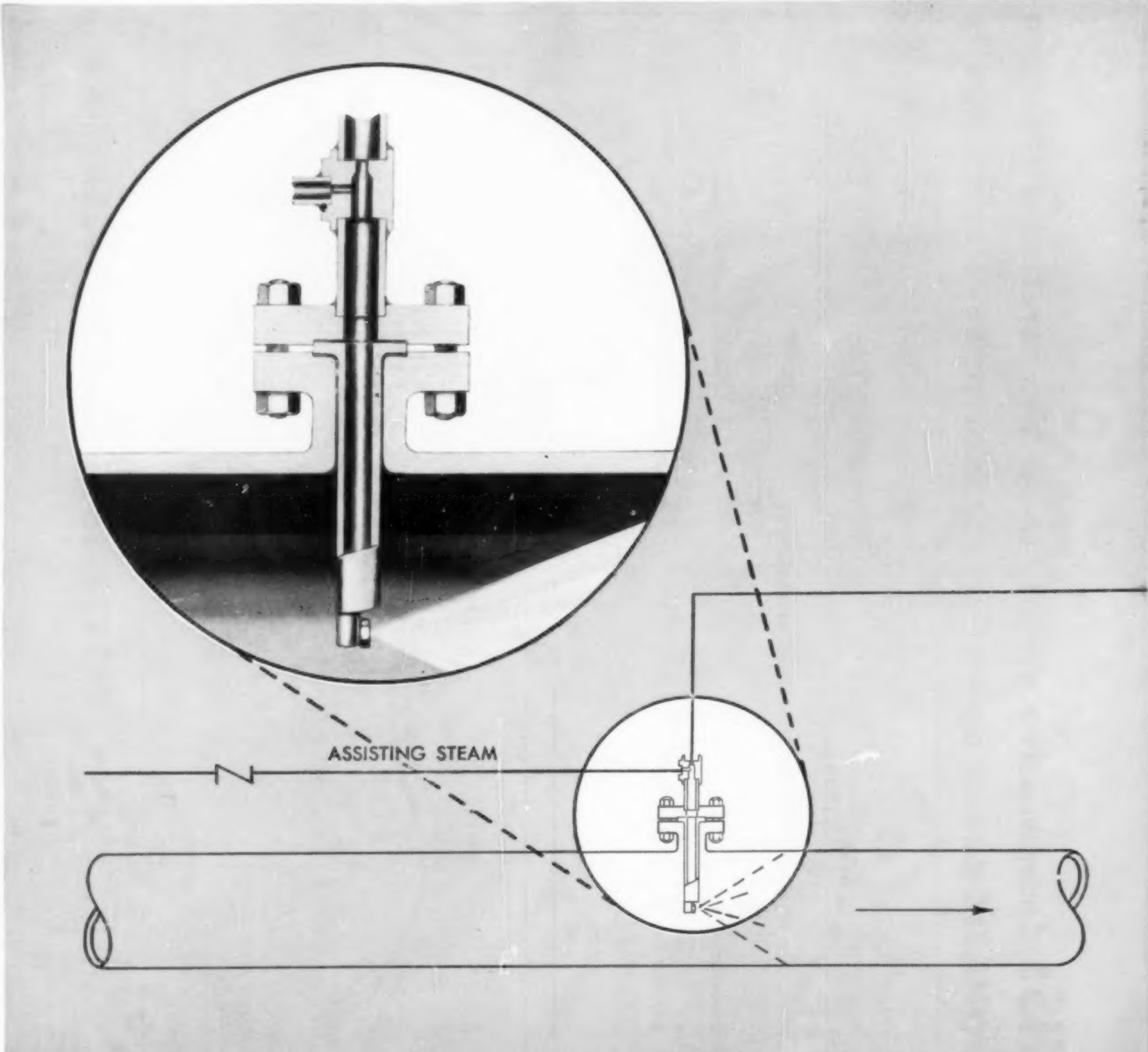

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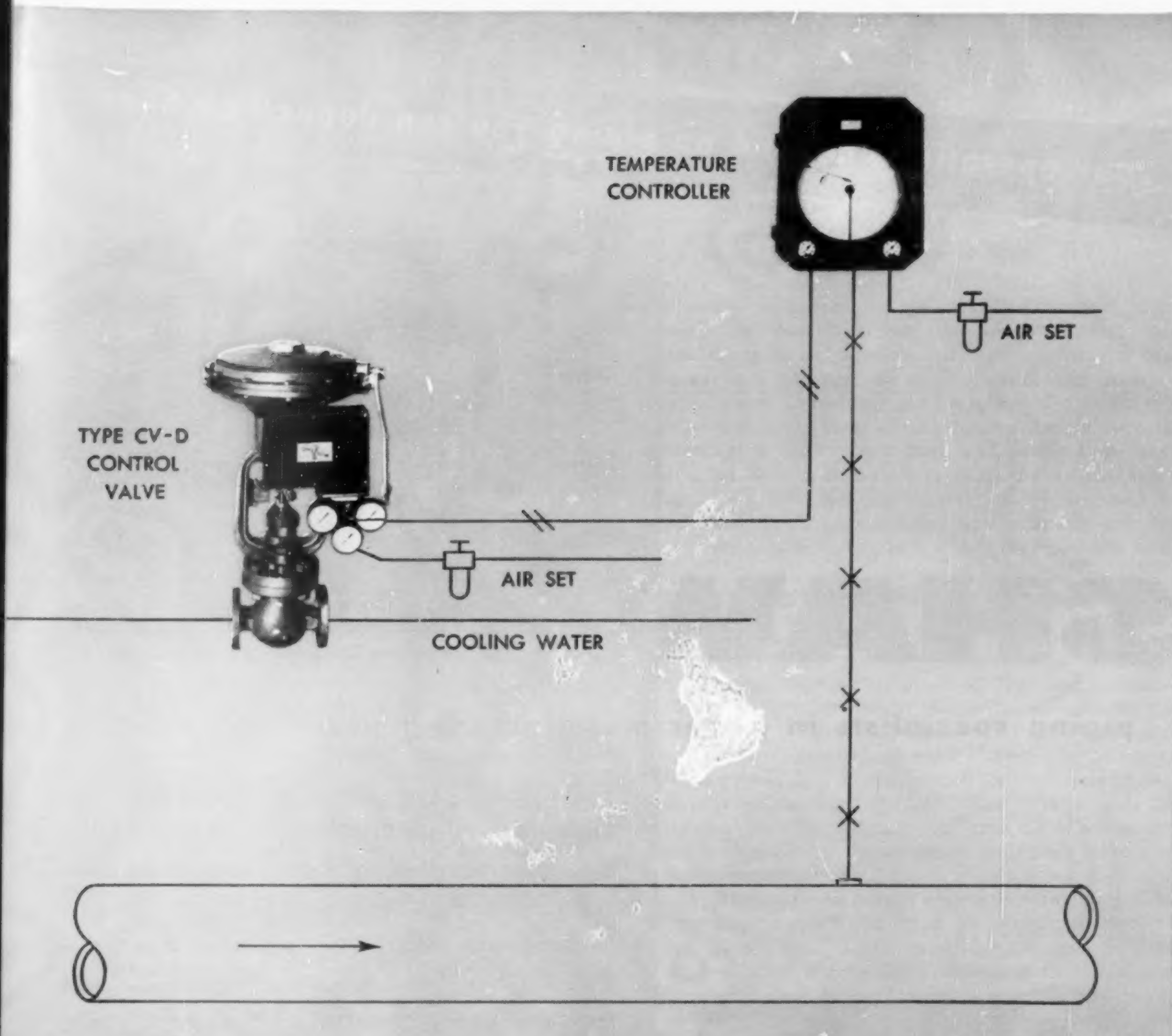

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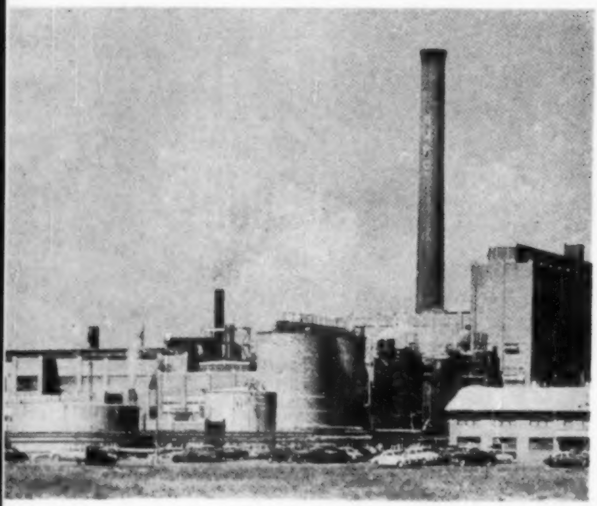

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COMBUSTION

Editorial

Progress in the Making

Whenever a new technology appears or a new step seems possible in a long established technology there is always certain to be evidence of different camps forming. There are those who believe the only course to take is one of immediate, full-scale attention to the new, others who seem inclined to cling to the old and proved, and a third group, usually the majority, who are frankly deeply interested but who want to explore and then move ahead in a relatively orderly fashion. Today's power generation field faces somewhat this situation in the development of atomic electric power.

The recently concluded Semi-Annual Meeting of the ASME in Cleveland presented a paper which we felt was both timely against this backdrop and in the best interests of overall progress in the power generation field. This particular paper, by C. A. Dauber, Cleveland Electric Illuminating Co. (COMBUSTION, August 1956), did not discuss atomic power but it did deal with "the recent breakthrough of the critical pressure barrier for steam and water ... that provides a new tool for higher thermal efficiency." Mr. Dauber offered the background of his company's thinking and decisions to further the thoughts or answer the questions of other power industry men now probing the possibilities of supercritical pressure power plants. This rather frank bid for an exchange of views in open discussion is in excellent harmony with the basic purposes of engineering societies and the forums they promote.

Over and above the forum aspects of his paper Mr. Dauber acknowledged that the confidence his company feels in their Avon No. 8 Unit is based on the long range development work of the water conditioning industry now producing water purities unheard of a year or two ago, the experience in European installations that stands behind the controls envisioned for the supercritical boiler, the advancement of metallurgy especially in the piping field and "the company's policy ... to select steam conditions one step in advance of the most economical unit in order to contribute to the advancement of the art." This acknowledgment and the size and scope of the author's company's investment, we feel, are in the best traditions of the power generation industry. They represent both the industry's alertness to the new and its constant awareness of its stewardship responsibilities toward investor and customer in pushing for a prudent yet vigorous progress. They are the answer to those who feel atomic power development may not be moving rapidly enough.

The power generation industry has, by and large, proved itself ready, willing and able to evaluate and stimulate research, development and construction that will advance the promise of economical and practical electric power no matter what the source of basic energy. Up to now they have always been ahead of demand requirements with production techniques that have permitted them to hold back or delay the wave of rising prices. We feel confident that atomic power will be similarly appraised, promoted, and adapted into the power systems' economy and at the best possible time.

Optimizing Power Plant Components

Mathematics has found its way into virtually every area in the design of steam power plants. However, when economic factors are involved, the most advanced mathematical techniques continue to be arithmetical addition and subtraction, and the most rigorous approaches have involved "cut and try" methods. Actually there is a great deal of justification for these procedures, especially on the part of large public utilities and experienced consulting engineering firms, all of whom are capable of applying the necessary judgment factors in making economic evaluations.

Any decision to undertake a specific power project or to purchase a particular type of equipment involves many intangibles. While experience is one way to encompass these intangibles in a decision that combines both intuitive and logical factors, it is not the only way. A commendable effort to establish a sounder mathematical base for calculating economic balance was presented by Prof. W. A. Wilson of the Massachusetts Institute of Technology at the recent ASME Semi-Annual Meeting in a paper entitled "An Analytic Procedure for Optimizing the Selection of Power Plant Components."

Those to whom the sight of an integral sign brings unhappy recollections of college calculus will find Prof. Wilson's paper quite forbidding, as will those whose prejudices have been hardened against a mathematical approach to economic problems. But engineers who are willing to assume an open-minded attitude toward a technique that gives promise of reducing the number of intangibles in cost evaluation and of offering a common basis for economic comparison of steam power plants will wish to study and possibly extend the techniques proposed by Prof. Wilson. Certainly the goal of representing station components by an idealization that is simple enough to be manipulated mathematically and sufficiently true to reality to aid in making decisions is a worthy one.

Fig. 1—Bankside boiler 2,934 hours' operation, 2/16/54
Air heater, top of lower bank, looking toward air inlet.

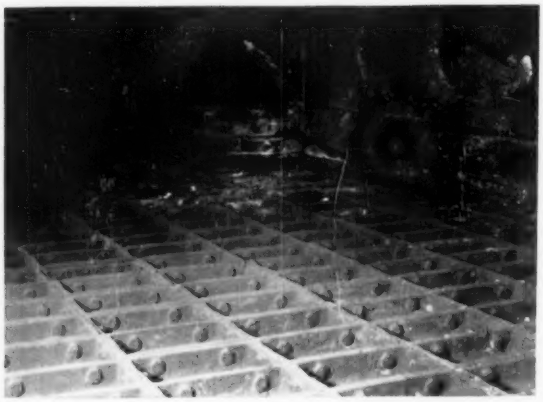


Fig. 2—Bankside boiler 2,934 hours' operation, 2/16/54
Air heater, top of lower bank, top of tubes in middle section.

An Investigation into the Air-heater Corrosion of Oil-Fired Boilers*

By B. LEES, M.Sc., A.R.I.C., M.Inst.F.†

Central Electricity Authority

Severe air-heater corrosion has been experienced in the oil-fired boilers at Bankside Station, Central Electricity Authority. Methods which have been successfully applied to reduce the fouling and wastage are described. Future experiments to ascertain optimum operating conditions, and suitable air-heater design are also considered.

FOUR boilers have so far been erected at the Bankside Station, Central Electricity Authority. The normal economic rating of each boiler is 300,000 lbs per hr and the maximum continuous rating 375,000 lbs per hr. The designed superheater-steam temperature is 925 F and pressure 950 psi. The units burn a residual oil of 3.7 per cent sulfur.

The layout of a typical boiler is illustrated in Fig. 5. It will be observed that each section may be readily reached for cleaning. Drainage facilities are provided for water washing the superheater, economizer and air heaters. The secondary air heater is a normal mild-steel tubular air heater, and the primary air heater is a cast-iron tubular type with gills on the air side.

The specified flue-gas exit temperature is 330 F at normal economic rating (n.e.r.) and 350 F at maximum continuous rating (m.c.r.). These temperatures, which are considerably above normal flue-gas exit temperatures with coal-fired boilers, were adopted in order to avoid excessive air-heater corrosion.

When these boilers were brought into operation it was found that, in order to obtain the required superheated-steam temperature, 910 F, it was necessary to operate with more excess air than desirable, the CO_2 content of the flue gases at the economizer outlet generally being 10 to 11 per cent. For optimum efficiency it was desirable to operate with about 13 per cent CO_2 at the economizer outlet, but under these conditions the superheated-steam temperature dropped to about 820 F.

Occurrence of Air-Heater Corrosion

Blockage of tubes at the air inlet to the primary air heater was observed soon after the boilers were commissioned. In 1953 investigations were initiated to overcome the corrosion and fouling of the primary air heater.

As an example of the severe nature of the corrosion, it was necessary to withdraw boiler No. 2 from service after only 934 hr operation. Figs. 1 and 3 illustrate the severe blockage encountered at the end of this period.

Internal caliper measurements were taken of the tubes to ascertain the rate of wastage. There are 48 tubes across the air heater from the air inlet to the air exit. These are cast in sections, each section containing three tubes, so that there are 16 sections across the air heater. Caliper measurements of the tubes at the top of the lower bank showed that the average rate of wastage at the air inlet, i.e., in rows Nos. 1 to 3 forming the first section, was at least 0.024 in./1000 hr and in rows Nos. 10 to 12 forming the fourth section, 0.014 in./1000 hr. These data indicated an extremely rapid rate of wastage, particularly as the estimates were probably rather low

* Presented before The Institute of Fuel, London, England, March 21, 1956, and published by permission of The Institute of Fuel Journal, 18 Devonshire St., Portland Place, London, W1.

† Combustion Technologist, London Division, Central Electricity Authority.

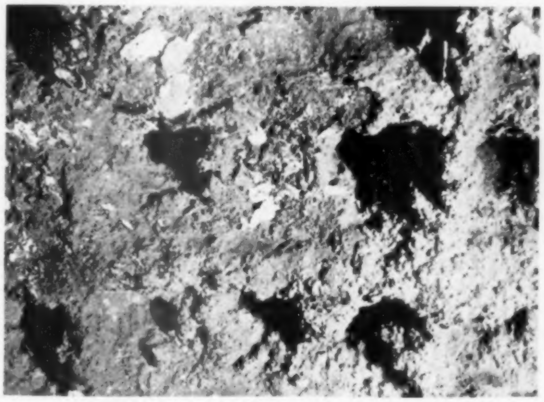


Fig. 3—Bankside boiler 2, modified, 1335 hours' operation, 2/14/55

Air heater, top of lower bank, looking toward air inlet.

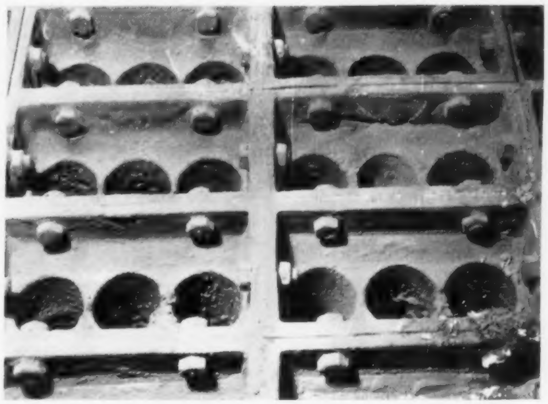


Fig. 4—Bankside boiler 2, modified, 1335 hours' operation, 2/14/55

Air heater, top of lower bank, top of tubes in middle section.

owing to formation of scale on the tubes. (See Figs. 1, 3.)

In dealing with this problem, the first consideration was to keep the boilers in commission. Dry-cleaning methods proved to be inadequate to deal with this rapid rate of fouling. Off-load water washing of the air heaters was eventually adopted, but the fouling and blockage of some of the tubes at the air inlet was extremely severe and the deposits were difficult to remove. Eventually it was found that by water washing at 500-hr intervals, by which stage the pressure-drop had not increased substantially, the units could be cleaned reasonably satisfactorily. While the air heaters were maintained in service by this procedure, the severe rate of wastage of the tubes at the air inlet was not appreciably reduced.

Investigations were initiated to ascertain whether the attack on the air heaters could be reduced. Experiments are still taking place, but this paper describes some of the methods used in the initial experiments and the success

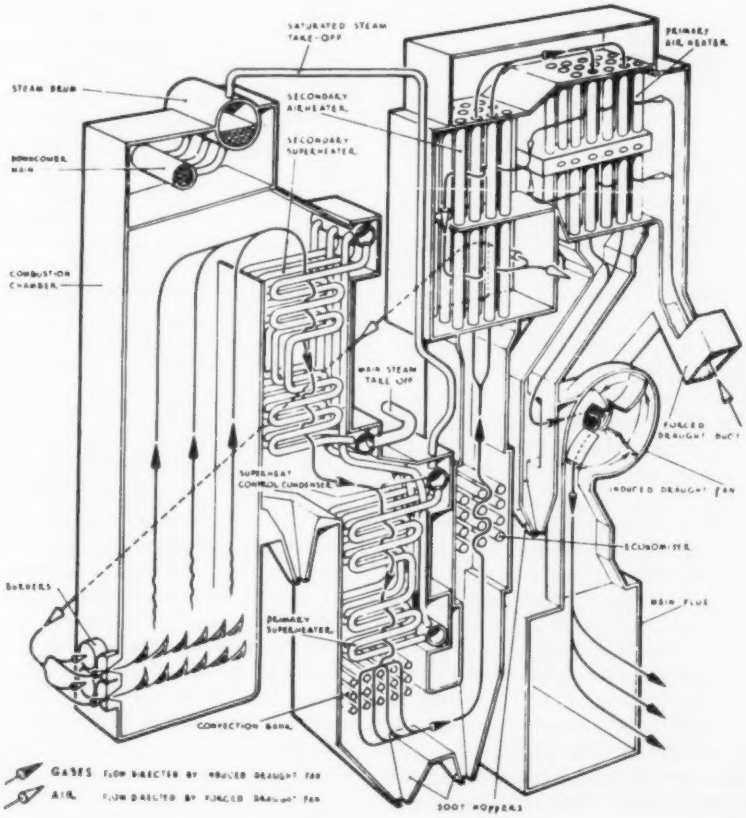


Fig. 5—Gas and air flow diagram

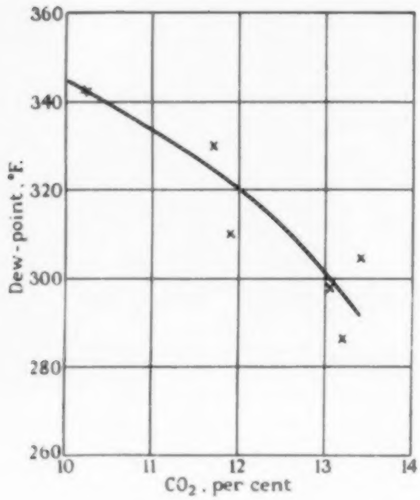
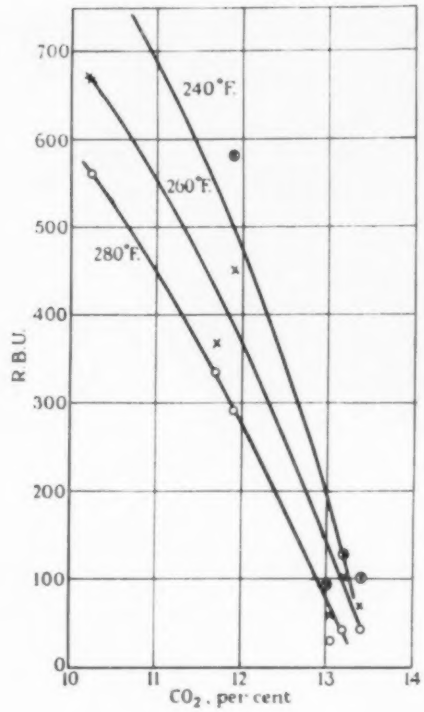


Fig. 6—Variation of dewpoint with percentage CO_2 in the flue gas

Fig. 7—Variation of rate of build-up with percentage CO_2 in the flue gas →



gained so far in reducing the fouling of the air heaters.

Investigations to Reduce Air-Heater Corrosion

Investigations were carried out in collaboration with Messrs. Charringtons and the British Coal Utilization Research Association, who, on the basis of the results they had obtained on injection of oil into coal-fired boilers to reduce the dewpoint of the flue gases (1),[1] suggested that similar experiments should be carried out on the oil-fired boilers at Bankside.

It was found that injection of oil into the base of the flame from the rear of the boiler lowered the dewpoint and the rate of build-up of a conducting film on the dewpoint probe. It will be recalled that the design of the boiler was such that in order to maintain the superheated-steam temperature it was necessary to operate with more excess air than was required for optimum combustion conditions, so that the percentage of CO_2 in the flue gases at the economizer outlet was 10 to 11 per cent. Up to 15 per cent of the total fuel consumed was injected without alteration to other operating conditions. This caused the CO_2 content of the flue gases to rise, but at the same time reduced the superheated-steam temperature. These conditions were possible to maintain for experimental purposes, but not for routine operation.

As this process successfully lowered the dewpoint and the rate of build-up, it was decided to determine whether similar results could be achieved simply by reducing the flow of primary air. Experiments showed that increasing the CO_2 content of the flue gases by this method gave a reduction in the dewpoint similar to that obtained with the injection of fuel oil into the base of the flame from the rear of the boiler. (See Fig. 6.)

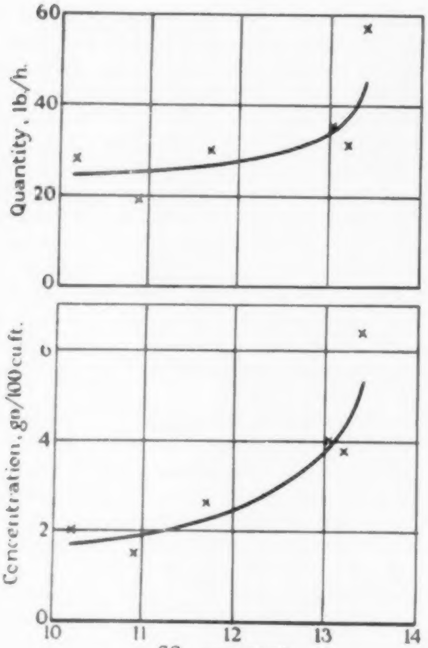
The variation of the dewpoint and rate of build-up (r.b.u.) of a conducting film on the dewpoint probe with the CO_2 content of the flue gases is illustrated in Figs. 6 and 7, the boiler operating at a constant load of 300,000 lbs per hr. An increase in the percentage of CO_2 in the flue gases from 10 per cent to over 13 per cent caused the dewpoint to drop from 345 F to below 300 F. Even more marked was the decrease in r.b.u., as shown in Fig. 7. Thus at 260 F the r.b.u. was reduced from 700 units at 10 per cent CO_2 to less than 150 units when the CO_2 content of the flue gases was slightly over 13 per cent.

While these experiments were being carried out the solid combustible matter present in the flue gases was measured using the apparatus described in the Appendix. As had been anticipated, the concentration of the solid combustible matter in the flue gas increased as the CO_2 content of the flue gases increased (Fig. 8). This effect was partially accounted for by the decrease in volume of the flue gases as the CO_2 content of the gas was raised. The quantity of solid combustible matter, however, also, increased, as shown in the upper graph, where this quantity is expressed in lbs per hr.

These tests also showed that when the CO_2 content was raised above $13^1/_2$ per cent at the economizer outlet there was a rapid increase in solid combustible matter and a smoky condition occurred. Radiovisor readings confirmed this observation.

As a result of this series of experiments it is apparent that to achieve the minimum rate of air-heater corrosion with a boiler fired with residual fuel oils it is essential to maintain the percentage of CO_2 in the flue gases as high as possible. The percentage of CO_2 in these boilers is limited to $13^1/_2$ per cent at the economizer outlet; if a higher figure is attempted excessive smoke is encoun-

[1] Numbers in parentheses refer to Bibliography at the end of the article.



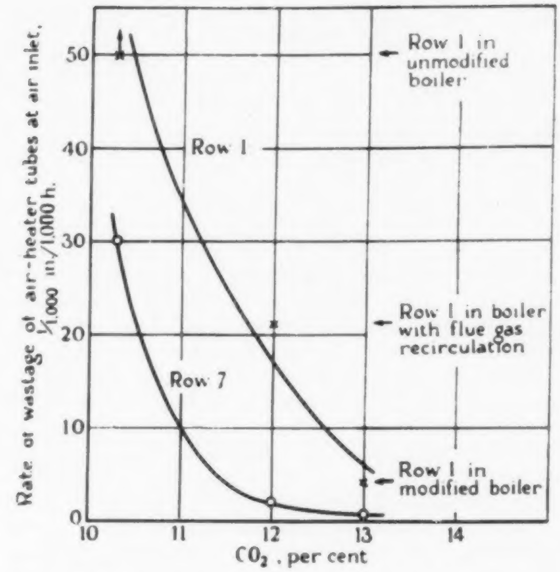


Fig. 8—Solid combustible matter in the flue gas

← Fig. 9—Variation of rate of wastage of tubes with CO_2 content of flue gas

tered. These are also the best conditions for maximum efficiency.

Crossley, Sweett and Poll (2) have suggested that the presence of carbon or carbon monoxide in the flue gases may have the effect of reducing SO_3 to SO_2, a theory which may account for these observations.

Modifications to the Boilers

The oil-fired boilers at Bankside generating station were the first large oil-fired boilers to be installed for power generation in England and to some extent, therefore, may be regarded as experimental. As originally designed, space was allowed for the installation of more superheater tubes if required. Operation of the boilers showed that when the percentage of CO_2 in the flue gases was 13 per cent the designed superheated-steam temperature, 925 F, could not be achieved and that in order to attain this temperature it was necessary to use more excess air, reducing the CO_2 content of the flue gases to 10 per cent.

Accordingly Boilers 1 to 3 were modified by introducing more superheater tubes and reducing the number of tubes in the convection bank and economizer, thus increasing the heat exchange in the superheater and yet allowing the flue-gas exit temperature to be maintained as designed, 330 F at n.e.r.

It was not possible to modify the fourth boiler in a similar manner at the same time because of load requirements, but it was thought that, as a temporary measure, gas recirculation should be introduced on this boiler. As it had been found necessary to introduce excess air in order to reduce the radiant heat exchange in the combustion chamber and increase the convection heat exchange in the superheater to maintain the superheated-steam temperature, a similar effect could be achieved by introducing flue gases instead of air. This would have the advantage that the boiler could be operated with a higher CO_2 content, increasing efficiency and reducing the dewpoint of the flue gases, and yet maintaining the superheated-steam temperature. Ducting was introduced to convey some of the flue gases from the outlet of the induced-draft fan into the air entering the forced-draft fan, relying on the pressure differential to achieve adequate circulation.

Effect of Modifications on Wastage and Fouling

A technique for measuring the rate of wastage of selected zones in air heaters has been described in a previous paper by the author (3). This entails measurement of the rate of formation of the soluble iron salts in the deposits which form on the air-heater tubes. At the same time as the experimental work was being carried out data was collected on the rate of wastage of the tubes under the various operating conditions.

A summary of the results of these measurements at the top of the bottom bank is given in Table I. This was the position where the highest rate of wastage was occurring.

Before the modification the rate of formation of deposits was rapid and the wastage of the air-heater tubes in the first row at the air inlet was well above 0.05 in. per 1000 hr in the most severe zone of corrosion, the top of the bottom bank, and even at the seventh row from the air inlet the wastage was 0.03 in. per 1000 hr. Caliper measurements of the internal diameters of the tubes at the air inlet mentioned previously confirmed this.

Table I compares the rate of wastage of the tubes before the modifications described and after the modifications had been carried out. In all the experiments the flue-gas exit temperature was maintained at 320 F. The results of these experiments are also illustrated graphically in Fig. 9.

TABLE I—RATE OF WASTAGE OF AIR-HEATER TUBES* UNDER VARIOUS OPERATING CONDITIONS: SAMPLES FROM TOP OF LOWER BANK

Conditions	CO_2, Per Cent	Rate of Wastage, In./1000 Hr Row 1 (Air Inlet)	Row 7
Original design boiler	10.3	Over 0.05	0.030
Boiler modified with increased superheater surface	13	0.0042	0.0008
Original design boiler with 9 per cent gas recirculation	12	0.021	0.002

* There are 48 rows across the primary air heater.

With the boiler modified by increasing the superheater surface area it was possible to operate with 13 per cent CO_2 in the flue gases while maintaining the superheated-steam temperature. The rate of wastage decreased from over 0.05 in. per 1000 hr to 0.004 in. per 1000 hr indicating that the useful life of the air-heater tubes at the air inlet was increased at least 10 times. The effect on the rate of build-up of deposits is illustrated by comparing Figs. 1 and 3 taken before the modifications with Figs. 2 and 4 after the modifications.

The ducting fitted for gas recirculation was only adequate to supply up to 9 per cent recirculation. It was desired to raise the CO_2 content of the flue gases up to 13 per cent, but it was found in practice that, with this limited recirculation, only 12 per cent could be attained while maintaining the superheated-steam temperature. Nevertheless, a considerable improvement in performance was achieved, although not so marked as with the boiler modified by increasing the superheater surface area.

Method of Cleaning the Air Heaters

Water washing has been found to be the most effective method of cleaning the air heaters. All the boilers have now been modified by increasing the superheater surface area. It is considered advisable to wash the air heaters every 1000 hr, although the increase in pressure-drop across the primary air heater after this period is negligible.

On one boiler, equipment has been fitted for washing during banked periods. Baffles have been fitted so that only the first 12 rows at the air inlet in the upper bank and 15 rows in the lower bank are washed. The baffles are to protect other tubes from splashing during the water washing process. The optimum interval between washings has yet to be determined. It should be emphasized that on-load water washing or washing during banked periods cannot be considered to be a cure for air-heater corrosion. It is essential to obtain a low rate of wastage before this process is adopted, otherwise frequent and expensive renewal of tubes will be required.

Future Developments

There has been a considerable gain in efficiency and availability of the air heaters in the oil-fired boilers at Bankside as the result of the experiments carried out so far. The main conclusion is that it is essential to maintain the CO_2 content of the flue gases as high as possible without causing excessive smoke. At Bankside this is achieved by operating with 13 to 14 per cent CO_2 in the flue gases at the economizer outlet.

To achieve optimum performance in future boilers it is apparent that similar conditions should be attainable. Before the modification to the boilers it was not necessary to use the superheater control condenser on these boilers, and even after modification it was only necessary to use it at the highest loads. As the load falls, the quantity of excess air has to be increased to maintain the superheated-steam temperature. This is an undesirable feature. In future design of oil-fired boilers it is suggested that maintenance of high CO_2 at lower loads may be achieved either by fitting larger superheater control condensers to lower the superheated-steam temperature at the high loads or by using gas recirculation for the lower loads. If gas recirculation is adopted it is desirable that an auxiliary fan should be fitted to recirculate the flue gases from the induced-draft fan outlet to the primary air inlet to the burners or to separate gas-recirculating ports, and the quantity of gas recirculated should be controlled from the panel.

No. 4 boiler at Bankside has been modified to operate at a lower flue-gas exit temperature than the other boilers (about 280 F), while maintaining a high percentage of CO_2 (i.e., the superheater-surface area has been increased, and there has not been a corresponding reduction in convection heating surface). This boiler will be used to ascertain whether the flue gas exit temperature can now be reduced to 280 F and possibly lower, without excessive air-heater wastage. This should effect an appreciable increase in efficiency when compared with the designed flue-gas exit temperature of 330 F at n.e.r. and 350 F at m.c.r.

Modifications to the air-heater design to reduce the air velocity across the tubes and increase the gas velocity through the tubes at the air inlet will be introduced in future work to achieve low flue-gas exit temperatures.

The use of additives for reducing air-heater corrosion is also being actively investigated.

Acknowledgments

This paper is published by permission of H. V. Pugh, the Controller, London Division, Central Electricity Authority. The author gratefully acknowledges his indebtedness to the Divisional Chief Chemist, E. A. Howes, for his support and encouragement; to J. E. Brown, for his assistance in developing the dust-sampling equipment; and to others of his colleagues in the Chemistry Section. This work would not have been possible without the close collaboration of the Station Superintendent and Staff at Bankside generating station. Also, he is indebted to Messrs. Charringtons and to B.C.U.R.A. for their collaboration in the initial experimental work, all the dewpoint measurements having been taken by the B.C.U.R.A. staff.

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APPENDIX: Apparatus for Determining the Concentration of Solid Combustible Matter in the Flue Gases

A diagram of the equipment is shown in Fig. 10. It consists of a light stainless-steel container, which when

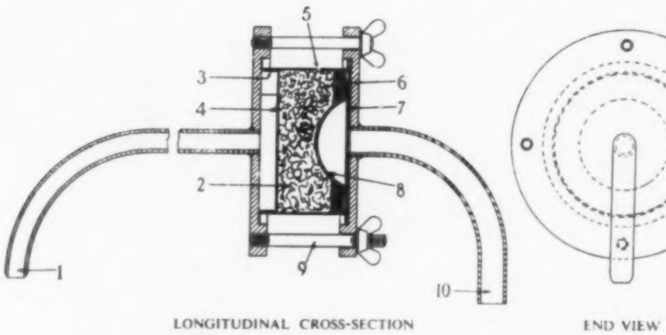

Fig. 10—Filter for the determination of the dust burden in flue gases

(1) Gas-sampling probe. (2) Lightly packed slag wool. (3) Spring retaining clip. (4) Coarse inlet gauze. (5) Filter container. (6) $^1/_4$ in. thick tightly packed slag wool around periphery of outlet gauze. (7) Sealing washer. (8) Fine outlet gauze. (9) Clamping bolts. (10) To flow gauge and exhauster.

loaded weighs under 200 g. The equipment is designed to have a comparatively large surface area at the gas inlet, 3 in. diameter, and yet can be weighed on an analytical balance. Glass wool may be used as the filtering medium, but for these tests slag wool was preferred. With the usual cylindrical type of filter there is a tendency, unless it is packed extremely carefully, for the gas to travel down the sides of the vessel, thereby passing the filtering medium. In this unit the outlet is a fine gauze in the outlet plate formed into a segment of a sphere. Slag wool is packed fairly tightly round the periphery of this outlet gauze to a depth of $^1/_4$ in. and the normal moderately light packing is used in the rest of the unit. Bypassing is not likely to occur, and the apparatus may be used with gas flows up to 200 cu ft/hr without excessive pressure loss.

The container is filled with dry slag wool, weighed, and clamped between the two end plates. The probe is inserted and the unit clamped to the side of the ducting. It quickly attains a temperature above the dewpoint of the gases; thus external heating is not required. To obtain the total quantity of solid matter in the gas stream, gas is withdrawn isokinetically through the unit for a given period and the container reweighed.

For all practical purposes, all the carbon collects in a thin layer on top of the filter medium. The top gauze is removed, dust brushed off into a suitable vessel, and the thin layer of slag wool and dust removed from the top of the container into the vessel. The carbonaceous material is burnt off at 500 C, and the loss in weight determined.

This equipment has also been found to be suitable for determining the dust concentration in the flue gases from coal-fired boilers where fixed-point sampling is required.

Hot Spring Meeting in Iceland

At the 5th World Power Conference in Vienna, Austria, June 17–23, 1956, there were a number of highly specialized as well as highly detailed papers. One report quite some off the beaten path described the use of natural heat in Iceland.

As reported by Gunnar Bodvarsson, the fissuring of the crust which initiates and accompanies volcanism and other crystal movements greatly influences the movement of ground water. Many secondary fissures reach comparatively great depths, and can thus act as channels for percolating ground water down to the depths where the crustal temperature is quite high, that is 212 F or 392 F, or more.

The water is heated in contact with the hot rock, and some of it finds its way to the surface again where it forms hot springs. The circulation is maintained both by hydrostatic head and convection in the long, very narrow fissures.

Hot-water springs of this kind are found in about 250 locations in Iceland. The temperature varies from 59 F to 212 F and the flow from a small fraction up to 250 l per sec.

The most important utilization of this natural heat in Iceland, so far, is for domestic and greenhouse heating. The city of Reykjavik, the capital of the country, having a total population of 62,000, has a central heating system utilizing natural-hot water which serves a total of 32,000 inhabitants and most of the downtown industrial and office buildings.

The Reykjavik Hot Water Supply System pipes the hot water over a distance of 16 km from a number of wells in a thermal area northeast of the city. The average temperature of the water at the wells is 189 F and the temperature drop in the main pipeline about 37.5 F, that is, the water reaches the city at a temperature of some 185 F. The total piping system in the city has a length of some 70 km and serves about 3000 houses. The average temperature of the water at the houses is about 167 F. This water is pumped through the radiators and wasted at a temperature of 95 F to 113 F.

*Problems Related To The Location Of Generating Plants, Transmission Facilities and Substations**

By L. W. CADWALLADER

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Projecting the electric utility industry's growth rate some thirty years, the author states, brings into focus the tremendous problem facing this industry in finding physical sites to locate the new power facilities to meet this load growth. Certain of the difficulties of site acquisition, today and into the future, are discussed.

BASED on past experience and predictions for the future, the electric utility industry can expect its load to approximately double once every 10 years. This rate of growth will vary somewhat from one section of the country to another. The southeastern area is one of the relatively high rate of growth areas.

The true significance of this rate of growth is not apparent until it is projected for a substantial period of time—say 30 years. Assuming the above rate of growth, the 1965 load will be twice the 1955 load; the 1975 load will be double the 1965 load or 4 times the 1955 load; the 1985 load thus becomes 8 times the 1955 load. This type of comparison brings into focus the tremendous problem facing the utilities not only in providing the new facilities required but also in finding a place to locate them.

The proper location of these new facilities is of vital importance because of the effect on economics of production, transmission and distribution. It is the purpose of this paper to discuss some of the problems related to the location of these new facilities.

Generating Plants

Generating facilities are generally the most difficult of all to locate due to the many major considerations involved—some of them governmental in nature. These may be tabulated as follows:

- I. Water
  - A. Supply
  - B. Pollution
  - C. Government Agencies
    - Corps of Engineers, U. S. Army
    - U. S. Dept. of the Interior
  - D. Fish Life
- II. Fuel
  - A. Sources of Supply
  - B. Railroad Facilities
  - C. Transmission of Power
- III. Taxes
- IV. Air Pollution

Water

With the associated problems of water pollution and fish life, and the varied and sometimes conflicting interests of the Corps of Engineers, U. S. Army, and other government agencies, water supply has become a major problem in some sections of the country.

In selecting a generating station site, whether steam or hydro, the availability of usable water, either for cooling purposes or for power generating purposes, is of course an important consideration. Not only must the water be available in the quantities required but the right to use it must be obtained from the governmental bodies having jurisdiction over it, since, apart from such riparian rights as may be vested in abutting landowners, water is considered to be a publicly owned natural resource, the use of which is subject to governmental regulation and control.

Even if a utility has vested riparian rights in a particular river, it will usually be necessary for the utility, in order to be able to utilize the river's waters for generating station purposes, to construct facilities of one kind or another in the river, and through regulating such construction the Federal and State governments can effectively regulate the use. In this manner control of the use of a river's waters may be vested in either the Federal government or a State government or both—depending on the nature of the river and its location.

Section 9 of the Federal Rivers and Harbors Appropriation Act of 1899[1] makes it unlawful (1) to construct any dam in any multi-state navigable river unless there shall have been first obtained the consent of Congress to the construction and (2) to construct any dam in any navigable river, whether or not multi-state, unless there shall have been first obtained the approval of the plans by the Chief of Engineers and the Secretary of the Army.

Similarly, Section 10 of the same Act[2] provides that apart from the dams and other structures listed in Section 9 of the Act, it shall be unlawful to build any other structure in any navigable river, outside established harbor lines, or where no harbor lines have been established, except on plans approved by the Chief of Engineers and the Secretary of the Army.

In 1920, Congress enacted what now constitutes Title I

* Presented before the Southeastern Electric Exchange, Augusta, Ga., April 12, 1956.

[1] 33 USCA Section 401.
[2] 33 USCA Section 403.

of the Federal Power Act[3] and thereby in effect delegated to the Federal Power Commission Congress' right to approve hydroelectric dams to be erected in multi-state navigable waters. Under that Act any utility seeking to construct a hydroelectric dam in any navigable waters must first obtain a license from the Federal Power Commission in addition to obtaining the approval of the plans by the Chief of Engineers and the Secretary of the Army as required by Section 9 of the 1899 Rivers and Harbors Act.

But if a utility desires to construct a dam in a navigable river for other than hydroelectric generating purposes (for example, in order to provide a pond as a source for cooling waters to be used in a steam-electric generating station), then, while no FPC approval is required, the utility must still, under Section 9 of the 1899 Rivers and Harbors Act, obtain the approval of the plans by the Chief of Engineers and the Secretary of the Army, together with, if it is a multi-state river, legislation evidencing the consent of Congress to such construction.

Since the Federal government's control is only over "navigable" rivers (or non-navigable rivers the flow of which affects navigable rivers), the question frequently arises as to what is meant by the word "navigable."

Prior to 1940, the rule for some seventy-five years had been that a river was navigable when navigability in fact existed under natural and ordinary conditions. In that year, however, the Supreme Court held, in *United States Vs. Appalachian Electric Power Co.*,[4] that when, by improvements with reasonable regard to cost and need, a river may be made available for navigation in interstate commerce, it is a navigable waterway of the United States even though such improvements have neither been made nor authorized—it is enough that they *may* be made. There the Court found the New River, in Virginia and West Virginia, to be navigable even though for the previous twenty-five years there had been no appreciable navigation of the river and even though the expenditure of large sums of money, not authorized or contemplated, would have been required to make it, in fact, a navigable waterway for interstate commerce.

Subsequently, in 1941, the United States Court of Appeals for the District of Columbia Circuit, on the basis of the *Appalachian* decision, held, in *Pennsylvania Water & Power Co. Vs. FPC*,[5] that the Susquehanna River in the vicinity of the Holtwood hydroelectric generating station was a navigable river. The Supreme Court subsequently refused to review the decision.[6]

The importance of these decisions may be judged by the fact that the dissenting Justices in the *Appalachian* case said as to the new test of improvability thus made:

> "If this test be adopted, then every creek in every state of the Union, which has enough water, when conserved by dams and locks or channelled by wing dams and sluices, to float a boat drawing two feet of water, may be pronounced navigable because, by the expenditure of some enormous sum, such a project would be possible of execution" (85 L. Ed. 266).

And in the *Pennsylvania Water & Power* case the Court of Appeals said, after comparing the history and physical characteristics of the two rivers (i.e., the New and the Susquehanna):

> "Enough appears from which to conclude that the Susquehanna, like the New, at different periods in the past has been used by vessels in interstate commerce of a kind, and that the former, like the latter, is susceptible in the future of being made navigable in interstate commerce if Congress should decide to appropriate the necessary money and to authorize the work to be done. And the showing of need is certainly no greater in the case of the New than in the case of the Susquehanna.... Neither, for a long time past, has carried any interstate commerce in navigation, and it may well be that in the case of the Susquehanna, as was declared by the Supreme Court to be true in the case of the New, there is no present need of improvements with the object of making the river usable for interstate navigation. But this question is no longer controlling" (123 F 2d 161).

It is clear that under the doctrine of these two cases there are very few rivers of any size which could not be considered to be navigable. Thus, if a river is a multistate one, Federal authorization is usually required for the construction of a dam or other structures in the river. At the same time, the laws of the State within which the structure is to be erected will have to be checked, since it is quite possible that both Federal and State authorizations will have to be obtained.

Of course, if it is decided that the river is not navigable and that interference with its flow will not adversely affect any navigable river to which it is tributary, then only the local State laws will be involved. In addition to laws regulating the construction of dams and other structures in rivers, many states have laws purporting to require the obtaining of a license before any use can be made of State waters, and these must be examined in connection with a generating station development. Frequently the utility will find that for reasons of policy it wishes to comply with such laws even though, as a matter of strict statutory construction or constitutional law, it may not be required to do so because the utility, as the owner of a generating station site bordering the river, is vested with riparian rights to make use of the waters of the river of which it cannot be deprived by a licensing statute which makes no provision for the payment of just compensation.

In addition to laws regulating the erection of structures in, and the use of, rivers and river waters, many States have adopted water pollution control laws for the purpose of protecting the waters of the State from industrial and other pollution. These laws are usually administered by boards or commissions appointed by the State executive and normally require an industry or other creator of waste to obtain a license prior to discharging the waste into any river within the boundaries of the State. In this connection, it is important to remember that the cooling water from a steam-electric generating station is generally considered to be waste matter under these laws so that a license must be obtained from the pollution authority before it may be lawfully discharged into the waters of the State.

Steam-electric generating facilities can be constructed so as to have essentially no detrimental effect on the river

[3] 16 USCA Sections 791a–823.
[4] 311 US 377, 85 L. Ed. 243.
[5] 123 F 2d 155.
[6] 315 US 806, 86 L. Ed. 1205.

or stream on which they are located. Normally a generating plant consumes very little water. It is true a large quantity of cooling water is required for the plant condensers but all this water is returned to the river. In the event natural stream flow is insufficient during dry periods, cooling towers can be provided for supplementary operation. In this connection, it is the author's opinion that cooling towers will, in the future, play an increasingly important part in the selection of steam power plant sites.

The Corps of Engineers, U. S. Army, in a recent case, after careful study by themselves and qualified consultants, admitted that a proposed steam-electric generating station would not in itself have any significant effect on the quality or the quantity of the river water. Nevertheless, they took the position that river water quality would be affected if the utility plant attracted the equivalent of two medium-sized industries engaged in manufacturing processes in which organic wastes were discharged. In this particular case, both States involved had water pollution control laws which were administered by capable personnel who could effectively control the location of additional industry along the river.

The most recent addition to the many aspects of water pollution may be termed "temperature pollution" or "heat pollution." Heat pollution should not be viewed with alarm but rather with scientific understanding and proper engineering layout and design. Rivers and streams are capable of dissipating tremendous quantities of heat in relatively short distances due to the evaporative cooling effect of air on the surface of the water. Rivers that have relatively low velocity show substantial temperature reduction per mile and such cooling rate is increased when water flows over a dam or through rapids.

High dams for water storage and hydroelectric power development result in the impoundment of water for long periods of time. Contrary to popular understanding, this may have an adverse effect on the quality of the water due to degrading of water in bottom of reservoir because of stratification. When stratification occurs there is a seasonal turnover resulting in delivery of water low in dissolved oxygen and often containing objectionable concentrations of organic solids and other contaminants.

Another important problem, which must be kept in mind during layout and design, is the possible effect on fish life. Various groups of sportsmen, Federal and State Fish and Wildlife Services, and other groups, are much interested in this problem. Expert advice can be of invaluable assistance in developing layouts which are the least objectionable from the standpoint of fish life.

Fuel

The availability and flexibility of fuel supply and the delivered cost of fuel in cents per million Btu is another item of major importance in selecting a new plant site, because the fuel cost per kwhr generated represents in the range of 70 to 80 per cent of the total production cost.

Coal, of course, is the major source of fuel and accounted for 68 per cent of the electrical energy produced in steam generating plants in this country in the year 1955. Coal consumption by the utilities in 1955 amounted to 138 million tons. Railroad freight rates are high and it is not unusual for the railroad transportation charge per net ton to be equal to the cost of the coal f.o.b. mine. In addition, the railroad freight rates for transporting coal do not always bear a realistic relationship to the mileage of the haul.

This unfavorable freight rate situation for coal is influencing the selection of new generating station sites. More consideration is being given to the selection of plant sites as close as possible to the coal mines. This trend has been aided and accelerated by the development of 330-Kv transmission facilities.

Furthermore, high freight rates for coal have given considerable impetus to the search for alternate methods of conveying coal from the mines to the consumer. For instance, the Pittsburgh Consolidation Coal Company, the world's largest bituminous coal producer, is pioneering in the development of transporting coal by pipeline. The above company is presently constructing a 110-mile pipeline from eastern Ohio to Lake Erie which is scheduled in operation early in 1957. In pipeline haulage, the coal is mixed with water to form a "slurry" which is pumped to its destination where it is de-watered and dried.

Taxes

In view of the complacent attitude taken by the public and politicians toward the lack of taxation of public power systems, it may appear somewhat unnecessary to list this as one of the factors affecting plant location. Nevertheless, it should be borne in mind that the question of which county or which state would receive the taxes levied against a large generating station to be constructed by an investor-owned utility, can have a determining influence on the location of the new facility.

Air Pollution

Since World War II, there has been growing concern on the part of Government, civic organizations and the public in general over the matter of air pollution. This has tended to focus attention on the stacks of large steam power plants, particularly those in congested areas.

For a number of years, the electric utility industry has been the largest single consumer of coal and, for this reason, has been susceptible to being pointed out as a source of air pollution.

The utility industry has responded to this challenge by taking the lead in closer supervision of plant operation and in the installation of mechanical and electrostatic dust collector equipment, proving beyond any reasonable doubt that modern steam-electric generating stations can be built to be a "good neighbor."

Transmission Facilities

Transmitting large blocks of power from generating stations to load centers is becoming an extremely serious problem because of the need for land to meet expanding residential, commercial and industrial requirements. Apart from the high prices brought about by the demands of developers for land in suburban areas, there is, of course, the related problem of finding suitable locations for high voltage overhead lines. With the capital cost of underground transmission ranging from 4 to 12 times more than the cost of equivalent overhead facilities, it is

obviously to the advantage of the utility and its customers to adhere to overhead construction wherever possible.

The purchase of transmission line right-of-way in areas which are suitable for development must be on a basis which will protect both the property owner and the electric company. It is not fair to the owner to ask him to sell rights which would leave him with a taxable interest in property he could not use for any purpose except farming or gardening. Likewise, the utility is not fair to itself if it does not buy adequate rights-of-way for present and future construction, including modifications which may be brought about by improvements in the art of transmitting electricity. The obvious answer is to purchase right-of-way in fee simple and to make sure that the width acquired will accommodate the present and prospective facilities. Many utility companies, operating in growing areas, follow this practice.

However, some companies still live in the days of right-of-way easements. Easements can be of many types from the simple form of the right "to construct, operate and maintain" to the complex form which is almost the equivalent of a fee simple title. However, it is doubtful if there has ever been an easement grant which clearly defined all of the rights of both parties. Perhaps a few cases will illustrate such conflicts of interest.

In 1923, a 69-kv steel tower line was built from Holtwood to York, Pa. The easements were for "a free and uninterrupted right-of-way...for the purpose of constructing, maintaining and operating...a line or lines for the transmission of electric current...together with all necessary towers, structures, poles, hangers, wires, cables, attachments and other appliances." No width of right-of-way was specified. The line constituted the main source of supply for York and interruptions were so frequent due to lightning that in 1937 it was decided to improve the line by the addition of an overhead static wire and an underground counterpoise connected to the existing towers. This construction work was stopped by a property owner, a shotgun and a police dog. After prolonged litigation, the Supreme Court of Pennsylvania held that the property owner was right and that the utility had exhausted its rights when the line was first built. In other words, the proposed installation of a single overhead wire, together with two small wires buried at least two feet below the surface of the ground, constituted an additional servitude upon the land for which additional rights had to be acquired from the owner. This ruling applied to all similar easements and resulted in the removal of the wires in other locations when demands were made by property owners.

In another case involving a 69-Kv pole line located upon an easement right-of-way in Maryland, the rights owned by the utility are so limited that there is a serious legal question as to whether any changes can be made to improve the line. If any proposed work should involve relocating structures or substituting steel towers for wood poles, there is no doubt that additional rights would have to be acquired.

Under Maryland law, the owner of an easement may be divested of his title when the owner of the fee interest permits his property to be sold for non-payment of taxes. The law apparently makes no provision for notice to the easement holder. As tax assessments rise and agricultural use is supplanted by residential subdivisions, the fee owners decide that they gain nothing by paying taxes on land they cannot make full use of so they simply stop paying taxes. The land in the right-of-way is then sold by the County authorities to the highest bidder and unless the utility learns about it by accident, a portion of its right-of-way may be lost unless it can purchase it from the tax sale purchaser or condemn it.

In contrast to these cases, let us consider the circumstances surrounding the purchase in 1932 of a right-of-way for a 230-Kv tie line between Baltimore and Washington. Studies made in 1932 indicated that a second line would be required at some future date. It was realized that between 1932 and the date of construction of the second line (now planned in part for 1957) ownership of the abutting land would change and that if easements were purchased, litigation would probably develop. Therefore, except in three special cases, the entire right-of-way, 250 feet in width, was purchased in fee simple. Today, much of this right-of-way is closed in by apartments, single family houses and other developments. Land values have increased from a range of \$500–\$1000 per acre in 1932 to a range of \$6000–\$8000 per acre in 1956. Furthermore, during the period from 1932 to 1956, the right-of-way, already occupied by one 230-Kv circuit, has been used for a distribution substation and a number of feeder lines. The fee simple title permits these uses without further negotiation. There can be no doubt that more of this type of long-term forward planning must be exercised by the electric utilities if they are to provide for the future needs of their rapidly growing service areas, and to accomplish this with a reasonable capital expenditure.

Substations

Substations, even residential type substations which are designed and built to conform with the architecture of the neighborhood, meet with strong opposition prior to construction. This attitude is often the result of fears arising from suspicion and lack of understanding on the part of citizens and organizations unwilling to accept at face value the factual information presented to them by the utility. After construction, it is not unusual to receive complimentary letters from persons or citizens' associations who originally were in violent opposition.

Usually, the principal stumbling block to a utility's use of a particular urban or suburban site for a substation will lie either in a local zoning ordinance or in private restrictive covenants which have been placed on the area by its developer with an eye to affording protection to its residents against the in-roads of nonresidential uses. A utility should endeavor to foresee these difficulties as much as possible and certainly must do everything possible to convince the zoning authorities and the land developers both of the essential nature of its substations and of their relatively insignificant effect on residential land use and values.

Summary

Investor-owned electric utilities, in seeking to locate their new facilities to best advantage for themselves and the public which they serve, will, in the future, be subjected to increased and varying influences. Satisfactory power plant sites, transmission rights-of-way for overhead lines, and substation sites will become increasingly

difficult to obtain at a reasonable price or, for that matter, at any price. As one result, there will be increased pressure brought to bear to force the utilities to put more of their transmission underground despite the greatly increased cost to the utility and its customers.

As greater demands are made on the nation's water resources by local, State and Federal agencies for municipal water supply, irrigation and sewage disposal; as the upsurge of industry feels the pinch of a dwindling availability of water for its manufacturing processes; and as the local water pollution control boards strive to coordinate the use and consumption of water and to control the discharge of municipal sewage and industrial wastes into the waterways, it can be anticipated that throughout the country, the question of water resources will become more and more of a national problem. This problem will become increasingly complex due to the many varied interests and influences—some of them political in nature.

Another consideration is the fact that "Uncle Sam" is by far the nation's biggest landowner. The U. S. Government owns 408 million acres of land or 21.4 per cent of a total land acreage of 1904 million acres. No doubt, this percentage will increase with time.

It is generally recognized that the Federal Government has substantial land holdings in the Western States. What is not generally appreciated is the extent of Federal land ownership in other states. Following are official figures for some of the Southeastern States.

FEDERAL LAND OWNERSHIP*
(As of June 30, 1955)

State	Million Acres	Per Cent of Total Acreage in State
Florida	3.5	10.1
Arkansas	3.1	9.2
Virginia	2.1	8.3
Georgia	1.9	5.2
Mississippi	1.5	5.0

* Inventory Report on Federal Real Estate Property in the United States as of June 30, 1955. Prepared by General Services Administration. Available at the Government Printing Office, Washington, D. C.

In view of all of the facts and considerations set forth above, it appears that in order to provide locations for essential facilities in the future, to acquire them at reasonable cost and to have them available when needed, we in the utility industry must do a better job of "looking ahead"—not just for 5 or 10 years in advance but for 25 to 30 years or more.

Economically Competitive Nuclear Power

Excerpted from remarks prepared by Kenneth W. Davis, Director of Reactor Development, U. S. Atomic Energy Commission before the 39th Anniversary Convention of the National Coal Assn.

We often talk about the "economics" of nuclear power and the woods are full of estimates of the "mills per kilowatt-hour" for nuclear power. What do we mean?

According to my concept, an economically competitive nuclear power plant is one which when built and run under normal and appropriate industrial financing and operating practices will produce power at the same cost as or at a lower cost than the *best* conventional power plant which could have been built at the same time and at the same location.

I believe that we may count our efforts as successful when this condition is met over some appreciable geographical areas of the United States. Although I believe that quite a number of large-scale nuclear power plants will be built in the United States before then, I do not believe that many plants will be in operation which will meet this definition before 1965 or possibly 1970. I believe this is a fairly optimistic prediction.

Part of the difficulty is that conventional plants are also responding to development work. Not only are great strides being made in the costs and efficiencies of such plants, but we may find much of the technology developed in the course of the search for nuclear power will be useful for conventional power plants as well. We must not fool ourselves by assuming that our goal is to compete with the average plant in existence today, or the average plant being built today, or even the best plants being built today. Nuclear power is going to have to compete with the best power plants which can and will be built in the decades to come.

The 450,000-kw, supercritical units recently announced by Phil Sporn for the American Gas and Electric System are a good example. These units were said to cost \$55 million each or a cost of \$122 per kilowatt and to give efficiencies of 41 per cent or 0.64 lb of coal per kilowatt-hour.

It can be easily calculated that these units *plus* all the coal needed to run them for 20 years would be furnished for \$255 per kilowatt with coal at \$4 per ton. This is just about equal to the lowest investment cost for any large nuclear power plants being contemplated today without any allowance for fuel costs. It indicates the improvement which is necessary before nuclear power plants can be expected to compete in the United States with modern conventional power plants utilizing cheap natural fuels.

However, we believe that nuclear power plants will be built one day which will have investment costs equal to, or at worst only slightly higher than, those for conventional steam plants and which will have operating and fuel costs equal to or substantially lower than average conventional fuel costs in the United States.

I would like to stress that there is no "law of nature" which requires this to be true. However, it is our best scientific and engineering judgment that it can and will be accomplished. It must be emphasized that we do not yet have the technology to do it and that a great deal of really difficult work lies ahead before it will be achieved.

*A New Way to Simplify the Steam Power Plant**

By H. A. KULJIAN† and W. J. FADDEN, Jr.,‡

The Kuljian Corp.

This paper presents a new approach to the problem of simplifying the installation and operation of steam power plants. Two alternative methods are involved, both of which combine regenerative feedwater heaters in a single shell. One integrates the closed-type heat exchangers; the other employs a new method of using open-type heat exchangers with intermediate locks. By either method, authors expect a saving in initial investment of from \$10.00 to \$15.00 per kw.

MODERN power plants are notoriously complicated and appear to the layman as a baffling maze of various machines, heat exchangers and tanks, all interlaced together with many pipes and valves of unknown functions. Yet, basically, all of this equipment in a steam power plant can be classified under three major groups; namely, the steam-generating unit, the turbogenerating unit, and the heat exchangers. All of the other equipment is either used to interconnect these or contribute to their operation.

Modern Power-Plant Equipment

The steam-generating unit includes the economizer, air preheater, waterwalls, superheater, forced-draft fan, induced-draft fan, pulverizers and furnace, in addition to the boiler itself. All of these are fairly compact.

The turbogenerating unit includes the condenser and controls, and it, too, is very compactly arranged.

But by contrast, the heat-exchanger equipment in a multistage bleeding installation usually includes several low-pressure heaters, a deaerating heater, high-pressure heaters with boiler feed pumps, and endless piping located wherever it can be squeezed in. The result is a complicated installation.

The importance of heat exchangers in attaining high thermal efficiency in modern plant operation is well known to all engineers. Going to higher and higher pressures and temperatures will not by itself answer the problem of better efficiencies for the steam power plant. This cannot be accomplished without the use of regenerative feedwater heaters.

In power plants most machinery such as circulating water pumps, condensate pumps, boiler feed pumps, forced- and induced-draft fans are all rotating apparatus either pumping water or air into the boiler furnace, or sucking the products of combustion from the furnace. They make a considerable amount of noise and hum in the power plants. In the heat exchanger, however, there are no moving elements. Only fluids are in motion; one is the water which runs through the coils with fairly high velocity, at the rate of 6 to 8 fps, the other is steam, which is bled from the turbine connected to the shell of the heat exchanger, being condensed continuously, transferring its energy into the water, thereby increasing the thermal efficiency of the plant. If it were not for these heat exchangers, it would be impossible to use generated power so cheaply in our industries or homes.

While the supercritical-pressure stations constitute a radical change in power-plant practice, by far the greatest change now imminent is the use of nuclear energy for generating electric power. Naturally, more complex equipment will be added. It is, therefore, of paramount importance that the feedwater heating cycle be kept as simple and as effective as possible.

Take for example a 150,000-kw unit. The condenser, with approximately 100,000 sq ft of condensing surface, is manufactured in a single shell. For the same size unit, eight single-stage heat exchangers are used with a combined total heating surface of less than one half that of the condenser.

The basic concept of incorporating all the stages of feedwater heating in a single shell reduces costs by:

(*a*) Requiring greatly simplified piping.
(*b*) Reducing the number of engineering drawings.
(*c*) Reducing installation cost and time.
(*d*) Reducing building volume, particularly valuable floor space.

In the aggregate, these four economies indicate a total saving of from \$10 to \$15 per installed kilowatt.

Proposed New Heaters

Two types of combined heaters are offered for both power plants and industrial plants. The closed heater will be referred to as Type K feedwater heater. The other is an open heater called Type K-F.

Type K Feedwater Heater. The type K feedwater heater is basically a series of closed shell-and-tube type heaters that have been combined in a single vertical shell, and factory-built and tested as a single unit. Flow is accomplished by pumping feedwater directly from the condenser hotwell through the coils of the stages directly to the suction of the boiler feed pumps. The suction-head requirements of the boiler feed pumps are satisfied by proper selection of the discharge pressure of the condensate booster pump. The tubes carrying the feedwater are arranged in flat spirals in the horizontal plane, and of such a size and number as to give the best heat transfer. Steam bled from the turbine at the desired point passes around these tubes to raise the temperature of the feedwater to the boiler and raise the overall thermal efficiency of the power plant.

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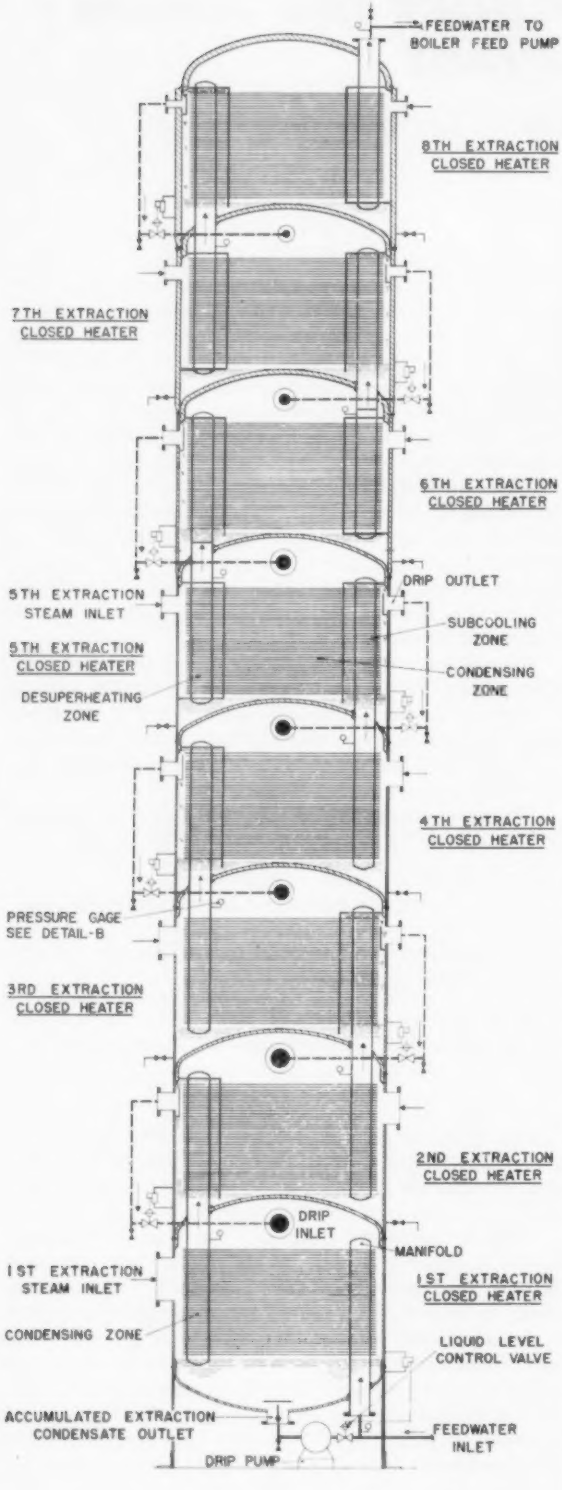


Fig. 1—"K" feedwater heater for 150,000-kw turbogenerator, 2000 psig, 1050 F, 1000 F reheat; diameter 10 ft, overall height 69 ft

Operation of K Feedwater Heater. Figs. 1–4 and the accompanying description are based on a 150,000-kw turbogenerator 2000 psig, 1050 F, 1000 F reheat, with eight stages of extraction heating.

The type K feedwater heater, with its spiral-wound heat-exchanger tubes, consists of a tower-like, cylindrical shell partitioned into stages, one stage for each heater.

This feedwater-tower assembly stands in a vertical position on the condenser floor, as close to the turbogenerator as possible, with the highest pressure stage at the top. Condensed extraction steam is cascaded from each stage heater to the next lower pressure unit. The condensate level in each stage is maintained with a level-control valve. The accumulated extraction condensate from the lowest pressure stage heater is pumped into the inlet manifold combining with the condensate booster-pump discharge. The stage-heater vents are also cascaded from one unit to the next lower pressure unit, finally cascading to the condenser.

Condensate from stage heaters, as well as from main condenser, enters the lowest pressure stage-heater manifold at the bottom. It then passes through a number of parallel coils into another manifold which becomes the inlet manifold for the next higher pressure stage heater. These manifolds are entirely internal and are welded to the partition plates at one point only, to allow free expansion of the manifolds and coils without causing any appreciable stress. The remaining stages operate in a similar manner.

In high-pressure stages of the feed cycle, energy is kept at the highest possible temperature level by use of desuperheating and drain cooling-zones. In drain cooling, entering feedwater picks up heat from the leaving condensate before it is flashed to the lower pressure heater and releases its heat at a lower temperature. The feedwater temperature is thereby raised a few degrees that it could not realize from the same heat in the lower pressure heater. In the desuperheating zone, the leaving feedwater picks up heat from the incoming superheated steam, thereby raising the water temperature higher than the saturated steam temperature corresponding to the pressure. The K feedwater heater includes both drain cooling and desuperheating zones as required.

The cycle efficiencies obtained by using the Type K feedwater heater are equal to those obtained by using conventional regenerative cycles.

Type K-F Feedwater Heater. The new Type K-F feedwater heater uses standard tray-type open heaters and deaerating heater, as now manufactured, which are combined in a vertical tower.

Flow from one heater to another is accomplished by gravity through a novel arrangement of receiving and discharging locks. A pair of locks is interposed between each heating stage. One lock is steam equalized to the heating stage immediately above and receives water from that stage by gravity flow. The other lock is steam equalized to the next heating stage and discharges water by gravity to that stage.

When a lock is emptied and the other is full, a transfer valve is automatically operated to interchange the functions of the locks so the full one discharges to the high-pressure stage and the empty one receives water from the low-pressure stage.

This operation continues with a frequency of transfer as required by the boiler load.

By this means water flows from the low-pressure stage to the high-pressure receiver without requiring pumps.

In the case of the open-type heater, feedwater is finely divided to mix with the extracted steam, since small particles present the most surface to absorb the vapor. Steam condenses on the water droplets heating them to a value approaching the boiling temperature. Direct-contact heaters remove all dissolved oxygen in excess of 0.03 ml per liter. When such a unit is designed to reduce the dissolved oxygen to 0.005 ml per liter, it becomes a deaerating heater (1).[1] Removal of dissolved gases depends on heating the feedwater to the boiling point, agitating it and presenting as big a surface as possible to liberate the gas and absorb heat by condensing the steam.

In the Type K-F heater, feedwater is fed into a series of trays and falls from tray to tray by overflowing. Steam completely envelops the trays, and heats and deaerates the feedwater along its path to the bottom of the shell. It is a well-known fact that direct-contact heating of feedwater has the advantage of 0 F terminal difference over that of indirect heating.

Operation of the Type "K-F." The K-F feedwater-heater-tower assembly is also a completely factory built and tested unit. It starts with the lowest pressure heater at the top, progressing downward to the highest pressure direct-contact heater and finally to the receiver at the bottom. The receiver is held at the same pressure as the highest extraction stage. The highest pressure extraction steam is first desuperheated in the closed heater, and enters the receiver at approximately saturated condition. The condensing zone for this closed heater is completely open to the steam space in the receiver. Condensed steam (drains) is automatically included in the receiver liquid space (refer to Figs. 5 and 6).

Inasmuch as the feedwater temperature at the boiler feed pump suction is below that for vaporization, these pumps will not get steam bound, but operate under a positive suction head at all times. With this design, net positive suction head for boiler feed pumps is no longer a station design factor.

Figs. 5 and 6 and the description below are based on a 150,000-kw turbogenerator, 1800 psig, 1000 F, 1000 F reheat, with seven stages of extraction heating. Refer to Fig. 7 for heat-balance diagram. The operation for the 150,000-kw unit is as follows:

Exhaust steam from the turbogenerating unit is condensed in the condenser and collected as condensate in the condenser hotwell. Makeup is added at this point. The condensate pumps discharge this condensate through the condensate control valve, to the condensate inlet at the top of the heater. Condensate enters the first heater by spilling over the edges of inlet distributing troughs in weir fashion, requiring only a very low head. Condensate is then intimately mixed with steam by spilling over the heating trays. Steam from the first extraction enters the heater uncontrolled, along with vented steam from the receiving lock.

The remaining open heaters operate in the same manner as just described. No storage is provided within each heater, however, as the receiving lock in each case acts as an effective storage compartment. With the exception of the lowest pressure heater which vents to the condenser, all other stage venting is taken care of by

[1] Numbers in parentheses refer to Bibliography at the end of the article.

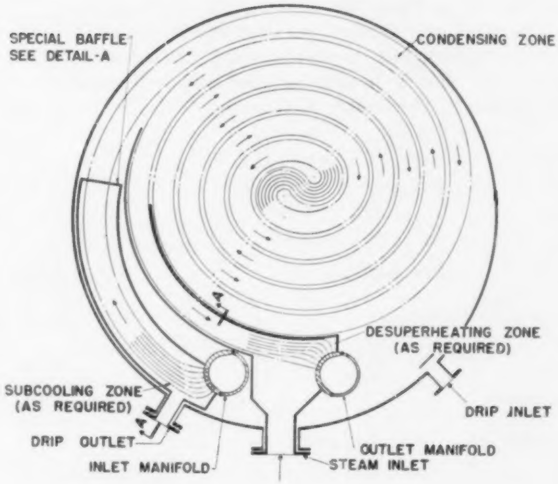


Fig. 2—Plan of typical extraction closed heater

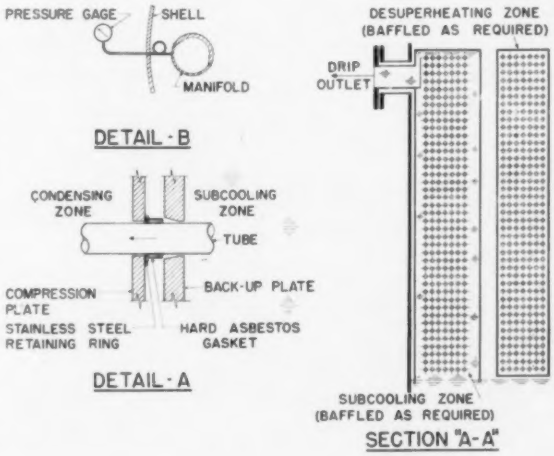


Fig. 3—Details of extraction closed heater of Fig. 2

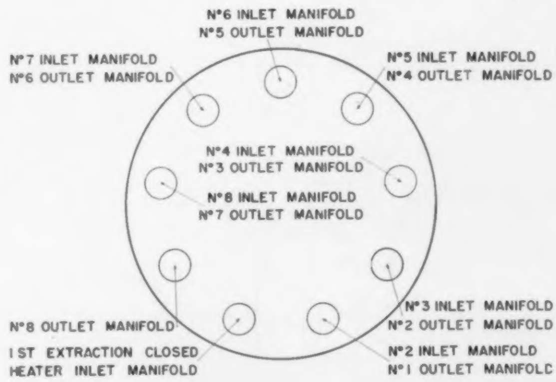


Fig. 4—Orientation of inlet and outlet manifolds

the equalizing steam connection. (See Fig. 7, p. 55.)

The receiver contains two desuperheaters, one for the 6th extraction and one for the 5th extraction. A 7th extraction closed heater is also mounted within.

Suction to the boiler feed pump is taken from the receiver and discharged through the 7th extraction closed heater to the boiler.

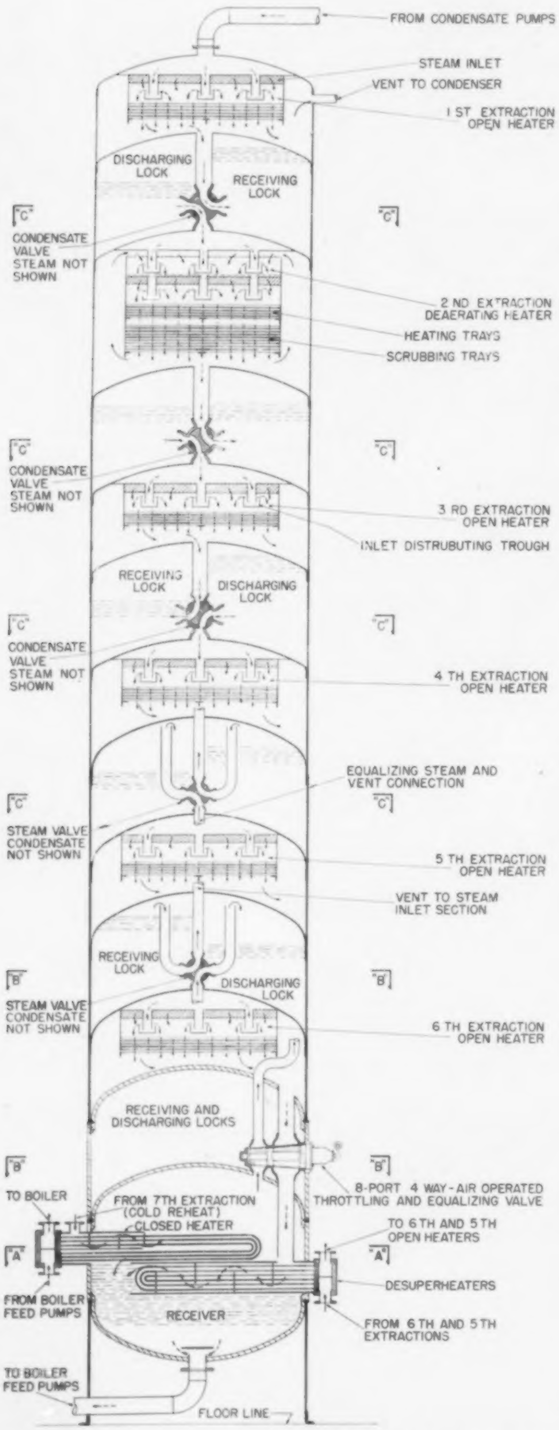


Fig. 5—"K-F" feedwater heater for 150,000-kw turbogenerator, 1800 psig, 1000 F, 1000 F

Control System. The control system for the K-F heater is designed to maintain a practically steady flow to each heater for a given load on the turbine, thus minimizing fluctuations in the extraction line pressures. Basically, the control system for each stage is made up of three elements: (1) primary demand, (2) correction for head variation, and (3) correction for flow to the succeeding stage.

Heat Balance. It is interesting to note that the heat rate for the regenerative cycle when using the K-F feedwater heater combined with a closed heater is better than that of the same cycle employing conventional closed heaters.

Fig. 7 is a heat balance for a 150,000-kw, 1800-psig, 1000 F, 1000 F, reheat, $1^1/_2$ in. Hg, preferred standard turbo-generator with seven stages of feedwater heating. With the exception of the direct-contact-heater terminal differences, the assumptions made were comparable to manufacturers' handbook assumptions; however, the heat rate for the K-F cycle is 0.425 per cent better than that found in the handbook (2).

Assumptions, (3):

(*a*) 3 per cent pressure drop turbine shell to extraction flange.

(*b*) 5 per cent pressure drop extraction flange to heater.

(*c*) Boiler feed pump power included.

(*d*) 900 lb per hr ejector steam.

(*e*) Generator H_2 pressure 0.5 psig.

(*f*) Zero per cent makeup.

(*g*) Ejector condensate leaves at 135 F.

It is possible in the foregoing heat balance to improve the heat rate still further by bettering the terminal difference of the high-pressure heater. The foregoing assumptions were made for comparison purposes. In the case of the 150,000-kw heat balance, the heat rate in Fig. 7 can be improved by approximately 8 Btu per kwhr by using the desuperheating coils for heater No. 6 to improve the terminal difference on heater No. 7.

Heat-balance studies of other size units indicate approximately $^1/_2$ per cent better heat rates than those found in the handbook, using the same assumptions.

Industrial Application Of "K-F" Lock For Single Deaerating Heaters

So far in this paper, multistage open-type heaters and utility-type installations have been discussed.

The new K-F lock arrangement described is applied to the single deaerating-heater installation for industrial use. The heater can be located at the same level as the boiler feed pumps, thus eliminating expensive supporting structure. In addition, savings will be made in the boiler-feed-pump horsepower and initial pump costs.

Where boiler drum pressure is maintained on the boiler-feed-pump suction, pumping horsepower need only overcome static head plus friction drop in piping.

Maintenance of K and K-F Feedwater Heaters. Reliability and ease of maintenance of equipment are always foremost in the minds of power-plant operating personnel; however, design engineers sometimes lose sight of these problems. In the K and K-F heaters, emphasis has been placed on rugged design and simplicity of construction for low maintenance problems.

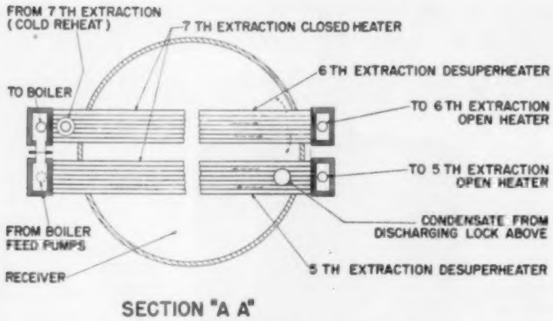
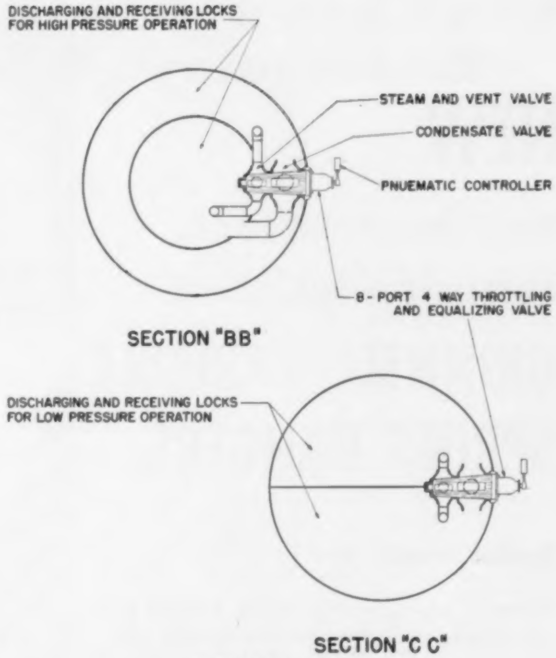


Fig. 6—Sections through "K-F" feedwater heater of Fig. 5



In the Type K-F feedwater heater, the valves and controls are of simple construction and require very little attention. Both open and closed heaters are provided with access manholes for easy inspection and maintenance.

Conclusion

The last decade was a tremendously active and stimulating one in the power industry. But the power engineer's problem, production of the maximum amount of power with the minimum amount of fuel, is still the same.

The complicated feedwater heating apparatus in present-day power plants must be simplified. The use of a single, integrated, multiple heat exchanger will substantially reduce building size, piping systems, erection time, and many other costs. Both the types described above are designed to meet this need for streamlining the modern power plant.

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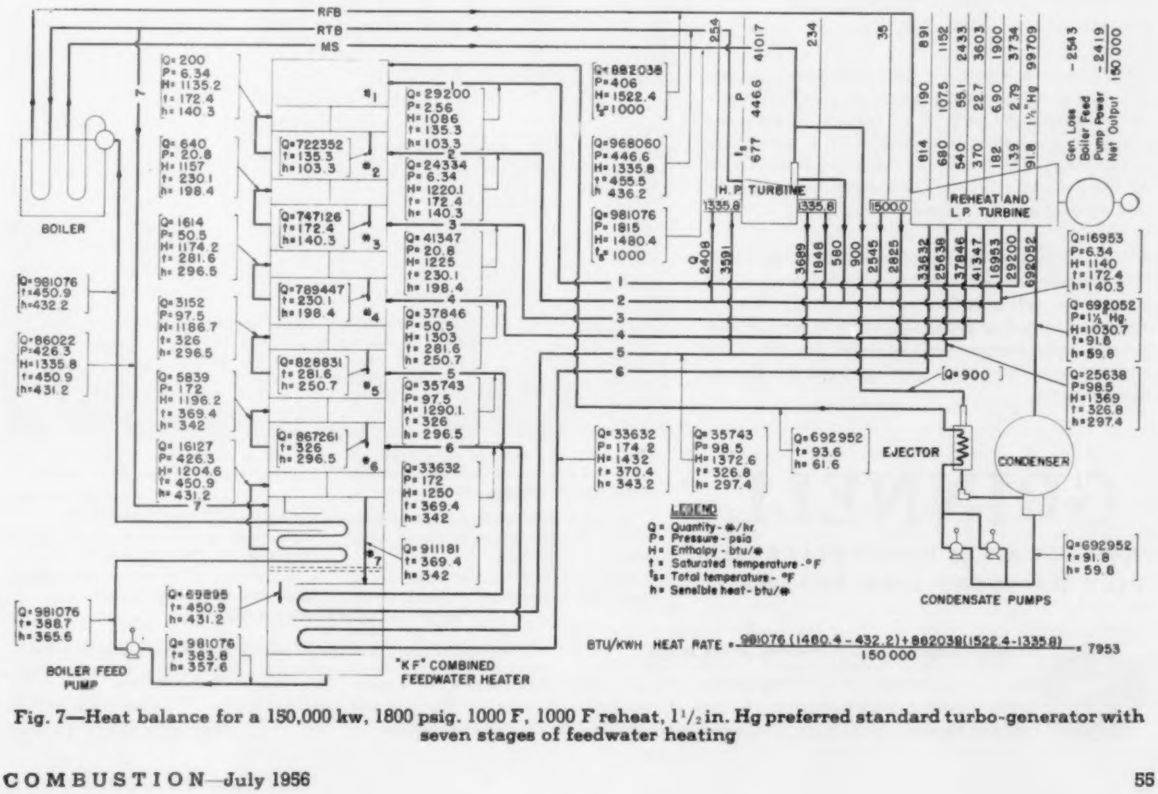

Fig. 7—Heat balance for a 150,000 kw, 1800 psig. 1000 F, 1000 F reheat, $1^1/_2$ in. Hg preferred standard turbo-generator with seven stages of feedwater heating

NEW

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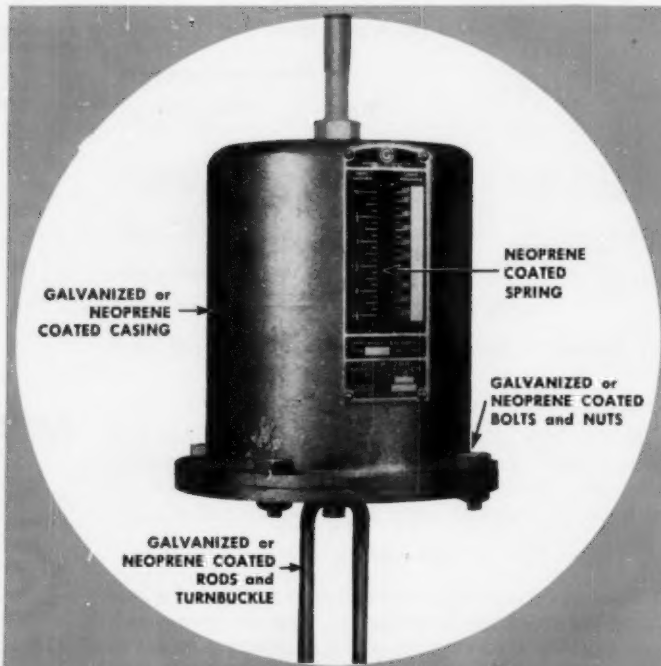

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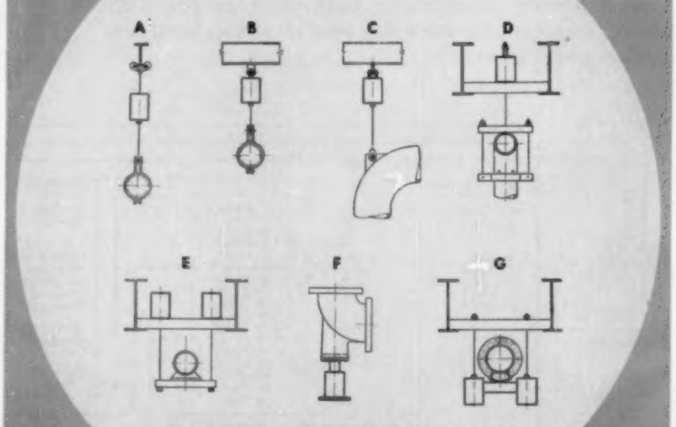

(A) Rod threaded to top cap (B) Furnished with single lug (C) Two lug style (D) Top adjusting (E) Adjustable top and bottom (F) For floor support (G) Trapeze assembly.

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The History of Ion Exchange and Some Interesting Recent Developments*

By O. M. ELLIOTT

Sun Oil Company, Philadelphia, Pa.

Ion exchange has proved a highly valuable tool to present day industry. This paper gives some interesting glimpses into the past history of ion exchange and describes certain of its more recent applications that foretell a strong future.

FOR at least ten thousand years man in his agricultural pursuits has been taking advantage of the ion exchange capacity of the soil. In fact, our food and our lives are dependent on ion exchange processes. If the top soil did not have ion exchange properties, the fertility of the earth would have been completely dissolved away by the rains of past ages and the chemical regeneration of the soil would be a much more costly procedure than at present. In recent years scientific understanding and advancements in the field of ion exchange have far outstripped the old rule of thumb approach and stagger the historian's ability to keep the record straight. But long ago farmers were operating king-size mixed-bed ion exchangers for growing their crops and were regenerating these mixed-bed units year after year with natural and chemical fertilizers and without the aid of much technical literature. And even some of the technical literature on the subject began to be printed in Elizabethan times. Perhaps many have the impression that ion exchange is essentially a process of the Twentieth Century. Yet Sir Francis Bacon, who died in 1626, wrote on the subject. Let me quote briefly from his Sylvia Sylvarium.

> "Trial hath been made of salt water passed through earth through (contained in) ten vessels, one within another, and yet it hath not lost its saltyness (so) as to become potable: (but when) drayned through twenty vessels (it) hath become fresh."

Thus, Bacon only missed founding the quantitative school of ion exchange thinking by ± five vessels.

Of course, Bacon's scientific writings are not read much these days, but we know that they were avidly read by the technical people of his time. In fact, he even ran a science-fiction department for things to come, along with his many other duties as public philosopher and Lord Chancellor of England. In "The New Atlantis," Sir Francis Bacon described certain imaginary water treating plants thus . . . "And we also have pools of which some do strain water out of salt and others do turn fresh water into salt."

As you know, even in this present atomic age we still have no commercial method for the large scale purification of sea water by ion exchange, although on less concentrated solutions we have surpassed all of Bacon's predictions. It is true that during World War II kits for easily desalting small quantities of sea water for consumption by marooned personnel were produced at high cost per ml of product. The difficulty in removing salt from sea water in large quantities by ion exchange is mainly a problem of the capacity per cu ft of the exchanger. Dr. Stephen Hales addressed the Royal Society on this particular point in the year 1739. Speaking on "attempts to make sea water wholesome," Hales reported that when sea water is filtered through stone cisterns "the first pint that runs through will be like pure water, having no taste of salt, but the next pint will be as salt as usual." This was more than two hundred years ago.

Ion Exchange In Soils

The ability of soil and clays to absorb components of manure liquors was studied during the early part of the Nineteenth Century on a more or less qualitative basis by Sir Humphry Davy, Gazzari, Lambuschini, Huxtable and others (1).[1] Gazzari even hinted that the process could be reversed to release these substances.

Although Fuchs (2) in 1833 reported that certain clays liberated potassium and sodium when treated with lime, the credit for the quantitative recognition of the phenomenon of ion exchange is generally attributed to Professor J. Thomas Way (3) and scientific gentleman farmer H. S. Thompson (4). One hundred years ago Professor Way was the consulting chemist for the Royal Agricultural Society of England and for fellow members he would do a soil analysis for three pounds. His "opinion on the genuineness of a manure sample," however, could be obtained for 7*s*, 6*d*. One day scientific farmer Thompson asked Professor Way's opinion on the genuineness of chemical "manures" he had used successfully. The use of ammonia sulphate as fertilizer was just beginning and practice again was advancing faster than theory. Professor Way therefore devoted many years of his life to re-establishing the proper relationship and as a side reaction made many pioneering observations and discoveries. Farmer Thompson was impressed by his observation that "manures such as potassium and ammonia" are taken up by the soil, strongly held despite the leaching action of rain, and yet are available to fertilize the growing plants. After many practical observations and chemical tests, farmer Thompson wrote a technical paper for the Royal Agricultural Journal. He thus informed Professor Way that . . . "when solutions of

* Presented before the 1956 Power Forum, Philadelphia Section, ASME, April 24, 1956, Philadelphia, Penna.

[1] Numbers in parentheses refer to Bibliography at the end of the paper.

salts of ammonia, potash, magnesia and so forth were made to filter slowly through a bed of dry soil five or six inches deep, arranged in a flower pot or other suitable vessel, it was observed that the liquid which ran through no longer contained any of the ammonia or other salt employed."

Professor Way carefully checked this on a laboratory basis and later wrote two then important papers in 1850 and 1852 which he entitled "On the Power of Soils to Absorb Manure." He found that the soil samples he used did not retain the whole compound but only the metallic part now known as the cation. When he made the experiment with ammonium chloride or potassium chloride he obtained calcium chloride in the filtrate in amounts equivalent to the ammonium or potassium that had been removed from solution. To us now it is obvious that the calcium loosely held in the soil had been replaced by the ammonium or potassium cations. But we must remember that in the 1850's the theory of ionic disassociation did not exist so that the replacement observation by Thompson and Way was a difficult philosophical step. This same cation replacement could be observed using sulfate or nitrate compounds. Sand did not exhibit the replacement phenomenon and there was no increase in the effect if more lime was added to the clay soil. The samples were probably low in humus and therefore the influence of organic matter on what we today term hydrogen ion exchange and anion absorption was not observed. Professor Way reported that this base exchange power was possessed by clay even in freshly dug samples taken from a considerable depth. He decided that "the idea of the clay as a whole being the cause of the absorptive property was inconsistent with all (of) the (then known) ascertained laws of chemical combination." He suggested that the phenomenon must be caused by the reaction of a calcium compound in the clay with the base that was replaced. After more experiments he concluded that the complex aluminum calcium silicates in the soil, (the zeolite silicates) were the active agents. He later synthesized a number of such compounds and found that they had this same base exchange property. Then he worked out what he considered to be the relative order of displacement of the base fractions. He also observed that the extent of exchange increased with concentration reaching a leveling-off value and that heat treatment destroyed the exchange power of the material.

In 1858 Dr. H. Eichhorn (5) reported on Professor Way's work in a paper entitled "On the Effect of Dilute Salt Solutions on Silicates." He showed that the order of displacement as described by Professor Way could be changed, or completely reversed, by varying the concentrations. Thus, the first faint recognition of the principle of chemical equilibrium appeared in the literature. But like Way and Thompson, Eichhorn also missed hydrogen ion exchange and anion absorption exchange. The acidic constituent in the filtrate in his experiments remained unaltered because he worked mainly with pure clays for which he had accurate chemical analyses.

The Base Exchange Process

Now the die had been cast for the base exchange process, but only for a one track process like a one track railroad running through the frontier. Others would later add the accurately measured milestones, the embankments, the cutoffs and later the parallel lines of tracks. Although most of the knowledge of base exchange was gained more than one hundred years ago, the second and third sets of tracks for hydrogen cycle exchange and anion absorption-exchange were not formally opened for traffic by industry until the 1930's. Farmers, however, went instinctively about their business of producing food by mixing humus with clay and sand, adding lime and regenerating the clay and humus with phosphates and nitrates and regenerating the clay with potassium and ammonia in the rule of thumb fashion. This paradox of practice outpacing theory is somewhat difficult to happily explain. Perhaps it was due to the slowness of acceptance of the theory of ionic dissociation.

While farmers were hard at work regenerating their mixed bed ion exchangers with lime, ammonium, potassium and nitrate compounds, working along a three lane manure wagon track, industry slowly started its one track base exchange railroad. Probably the first successful industrial applications of ion exchange were made by Gans (12) between 1900 and 1910. Gans employed both natural and synthetic aluminum silicates for softening water. In 1908 Harm treated sugar solutions. From here on the list of names contributing to the process rapidly grows out of all practical proportions to fairly distribute credit except for major developments. Please excuse me if I do not mention your name or company. Credit controversy extends all the way along the line and at least once required a decision of the U. S. Supreme Court (14).

As new types of ion exchange materials were developed, new industrial applications became possible. Although the siliceous zeolites exhibit some hydrogen exchange capacity they do not have long life and high capacity under these conditions. With siliceous zeolites it therefore was not practical to operate in the hydrogen exchange cycle for the simultaneous reduction of both the hardness and alkalinity of an industrial water supply. However, the development of the sulfonated coal-type cation exchangers called carbonaceous zeolites and the announcement by Adams and Holmes (13) in 1935 of sulfonic acid resins having high cation exchange capacity, together added another track to the ion exchange line. Inasmuch as both of these new materials have high capacity and are resistant to acid attack it finally became industrially feasible to regenerate the material with acid and to operate in the hydrogen exchange cycle. These materials, of course, can also be operated in the sodium exchange cycle. Thus, it finally became possible by ion exchange to reduce the dissolved solids of high bicarbonate waters at the same time that the hardness was removed.

Multi-Step Exchangers

Adams and Holmes (13) also added the third main track and made the ion exchange process into a rapidly growing trunk line of science and industry when in 1935 they also announced that polyamine type resins had been prepared that exhibited anion absorption-exchange properties. The deionization of water in a two step or multi-step ion exchanger was then attainable. The versatility of the new materials for ion exchange processes was promptly recognized, both by consumers and producers, with the result that new organic ion exchange ma-

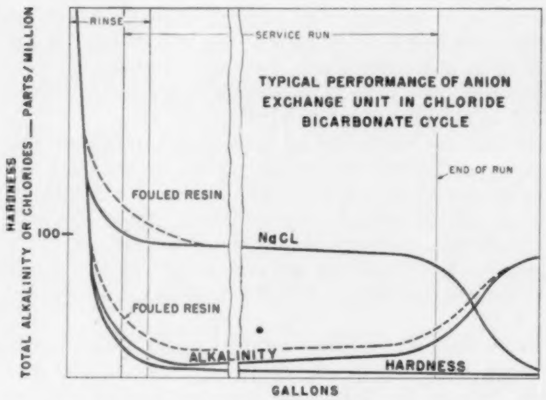

Fig. 1—Typical performance data for an anion exchange unit operating on the chloride bicarbonate cycle which is further described in text

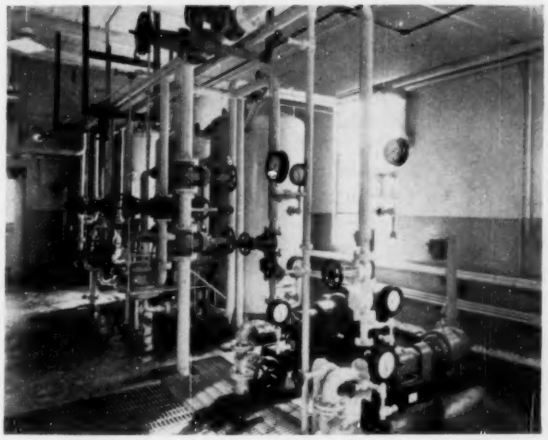

Fig. 2—Semi-automatic ion installation at the Sun Oil Co.'s Sarnia Refinery in Fig. 1

terials and processes are now being developed and set up almost faster than this historian can follow. The ion exchange manufacturers have taken on some of the characteristics of custom shop tailors with new ion exchange materials being quickly produced to fit specific industrial and biochemical needs. The new fields are multifold. This historical review will show only a few of the broad new branch lines that ion exchange has opened for traffic.

Farmer Thompson and Chemist Way would now have difficulty recognizing their off-spring. Ion exchange has finally leaped entirely beyond the agricultural and water softening applications. It now also operates in such widely divergent fields as the fine chemicals, the solvent chemicals, the alkaloid (15) and vitamin chemicals, the blood banks (16, 22), gas separation plants, peroxide production (30), deaeration (31), the dairy and ice cream industry, boiler water testing, the electroplating industry, the human alimentary canal, isotope disposal and separation (17–19, 27, 28), uranium recovery (34), and purification and in a host of other fields.

The annual expenditures for ion exchange equipment will help to bring ion exchange developments into commercial prospective. A. Mindler and C. Paulson attempted to estimate the sales volume of Ion Exchangers in 1954 before the uranium recovery development was declassified and they came up with the following figures:

Softening	$18,000,000 per year
Deionization without silica reduction	6,000,000 per year
Deionization with silica reduction	5,000,000 per year
Mixed-bed deionization	3,000,000 per year
Split stream dealkalization	2,000,000 per year
Dealkalization	1,000,000 per year

As you will see later in this presentation, this estimate does not include the uranium recovery development that was not made public knowledge until fairly recently.

At the Sun Oil Co.'s Sarnia, Ontario, Refinery we have had a 5 ft diameter anion exchange unit operating on the chloride bicarbonate cycle for about $2^1/_2$ years, Fig. 2. The unit was manufactured by a Canadian equipment company. There are brine wells on our Sarnia property so that the regenerating salt is practically free. We use this brine untreated except for filtering out suspended matter. This NaCl brine contains about 1 per cent $CaSO_4$ and 1 per cent Na_2SO_4 on a dry basis plus traces of Fe and Mg. In the beginning we tried preliminary precipitation treatment on the brine, but did not find sufficient over-all improvement to justify the additional expense and labor. We therefore discontinued the preliminary brine treatment.

The plant was originally arranged to backwash and rinse the anion unit with soft water from the cation units, but as the load grew we finally had to backwash and rinse the anion unit with hard City water and we only use soft water to finish the rinse. Thus, the anion resin has taken a considerable beating.

Fig. 1 shows typical performance data for this anion unit and how the performance falls off between chemical cleanups. About every second month we give the unit a treatment with sodium hypochlorite solution and a day later with cold sulfamic acid. The steel tank does not have a lining and we have found that the uninhibited sulfamic acid treatment does not significantly deteriorate the steel shell.

It is interesting to plot the total alkalinity of the rinse water during part of the regular regeneration. I have done this many times, taking samples and titrating them every minute through the first part of the rinse. The total alkalinity in the rinse water goes as high as 10 to 20,000 ppm for a few minutes, but the pH does not go above 9.0 during this operation. This apparently does not precipitate much of the potential calcium carbonate passing through the unit. If it did, we would be required to acid clean the resin much more frequently.

The boilers at our Sarnia Refinery are operated at 450 psig pressure and contain integral superheaters. We have not had significant scale accumulations in the boilers or carry-over problems.

Protein Separation

One of the new fields for ion exchange has been in the research separation of the proteins (23–26, 32). When the structure of a protein is broken down by hydrolysis, the wreckage is a tangled mixture of amino acids. These protein building blocks have been difficult to separate and purify. Amino acids have the interesting property of being acids and bases at the same time. They can therefore form negative ions, positive ions or neutral molecules, depending on the acidity of the solution and on the amino acid concerned. A cation exchanger will take up the positive ions and an anion exchanger the

negative ions while neutral molecules will not be absorbed. Amino acids can thereby be easily separated into these three groups. Ion exchange and chromatography can then go farther. These tools working together can separate individual amino acids, provided the amino acids in the mixture all have the same charge. This separation depends on the fact that all ions of equal charge are not held with equal strength by ion exchange material. In the case of the amino acids there are subtle differences in the strengths of attachment that make possible this difficult separation. Chromatography and ion exchange solve this and similar difficult separation problems. In this double technique a small amount of a solution containing the mixture of amino acids after preliminary separations, is poured into the top of a long column of exchange material. The top of the exchange column takes up all of the ions. Then a regenerating solution is slowly run through the column. The ions of the regenerant displace the amino acids from the top of the exchanger and force them farther down into the column. The amino acid that is least strongly held moves farthest down the column and is first to emerge from the bottom. The longer the column the greater the relative differences in the movements of the various ions. If the column is long enough, each amino acid successively comes out completely separated from the others.

This chromatographic ion exchange technique can also be used to separate the rare earth elements. The rare earth elements are so nearly alike in their chemical properties that chemical separation is extremely difficult. Before ion exchange and chromatography got together on this problem 95 per cent chemical separation purity was often difficult to attain. Now 99.99 per cent purity is possible. Similar separations between the "identical twins" of the periodic table, zirconium and hafnium (29), are practical.

Ion Exchange in Uranium Production

The important place of ion exchange processes in the uranium production program is a complete story in itself. In 1948 the Shinkelobwe mines in the Congo, the Eldorado mines in Canada and the vanadium-uranium mines of the U. S. Colorado Plateau were the only commercial sources of uranium for the free world. In addition, there were three known low grade sources in the form of South African gold tailing piles, domestic phosphate rock and the Chattanooga shale formations. However, to process even the richest of these low grade deposits would mean processing several tons of material to recover one pound of uranium oxide.

During the 1949 to 1952 period it became necessary for the A.E.C. to plan the Savannah River, Paducah and Portsmouth Plants and expansions at Oak Ridge and Hanford. Uranium recovery from the South African gold tailing piles by ion exchange was the key step and the only sure way to meet the new schedule for uranium even though the process had never been tried except in laboratory glassware. Two small pilot plants were placed in operation in the beginning of 1950 and by December of that year the process had been firmed up and the mill design was frozen.

In October of 1952 when the first plant was ready for operation a $65,000,000 construction program was under way with firm commitments for a much larger program and all based on small pilot plant operation. The West Rand plant had to work on schedule and it did. It has been operating continuously ever since and the uranium production costs have borne out the optimistic estimates based on the pilot plant data (35).

By 1957 the South African uranium program alone will have expanded into seventeen plants, drawing tailings from twenty-seven mines and will process over 20,000,000 tons of tailings annually for uranium. But this is only the start because large ion exchange uranium recovery plants for low grade ore are now being constructed or planned for the Belgian Congo, Australia, Canada and the U. S.

In the beginning of the laboratory work that led to this uranium recovery development, cation exchange was tried because at that time hexavalent uranium was thought to exist in solution solely as the uranyl cation. But these early attempts showed that cation exchange was not commercially practical because ferric iron, aluminum and other metals were absorbed along with the $\overset{++}{(UO_2)}$ cation. Fortunately, the $\overset{++}{(UO_2)}$ ion forms anionic complexes in a stepwise fashion with sulfate ions as follows:

$$(UO_2)^{+2} + n(SO_4)^{-2} \rightleftarrows [UO_2(SO_4)_n]^{2-2n}$$

where

n = 1, 2, or 3

The most abundant species present in a sulfuric acid solution of uranium is the anion $[UO_2\,(SO_4)_3]^{-4}$.

Another and even stronger complex exists in carbonate solutions of uranium.

$$(UO_2)^{+2} + 3(CO_3)^{-2} \rightleftarrows [UO_2(CO_3)_3]^{-4}$$

Unfortunately other anions such as chlorides, nitrates, bisulfates and complexes such as ferric sulfate and even sulfate ions compete with the negative ion complex of uranium for sites on the anion exchange resin. The problem was one of finding an anion resin that was selective enough for the uranium complex to make the process a commercial success. The quaternary ammonium anion exchange materials proved to have this selectivity.

The recovery and concentration system begins with a clarified sulfate or carbonate leach liquor, depending on which system is used. Starting with the anion exchanger in the nitrate or chloride form the leach liquor is passed through a series of anion resin beds. Nitrate, or chloride ions in the resin are replaced by sulfate, bisulfate, uranium sulfate or carbonate negative ions and other complex ions. When the resin becomes preferentially loaded, the uranium complex is eluted by treating the bed with nitrate or chloride ions in high concentration. No other regeneration cycle is necessary.

Uranium is finally precipitated from the concentrate as the hydroxide using ammonia or some other alkaline agent. The precipitate is filtered and dried. Some iron complex may be retained by the resin and is eluted with the uranium complex. After concentrating to a uranium content of about 5 per cent, the bulk of the iron is removed as an easily filtered precipitate in the presence of sulfate under controlled pH conditions (37) of about 3.0 to 3.8. The iron precipitate is dissolved and the solution obtained is electrolyzed to plate out various metallic contaminants away from the uranium; the uranium containing solution from this step may be combined with the

filtrate from the iron removal step and treated to recover the uranium. Approximately 98 per cent of the uranium in the leach liquor can be recovered as a concentrate having a U_3O_8 content of 80 per cent to 90 per cent (36). This process is used on gold ore tailing piles having a uranium content of only 0.1 per cent as U_3O_8.

The South African program when completed will include eight flotation plants to also process half of the gold tailings throughput for pyrite. Seven sulfuric acid plants will burn 480,000 tons of pyrite per year to produce 540,000 tons of sulfuric acid to operate the uranium recovery plants. By 1957 the total cost of the uranium recovery, the flotation and the sulfuric acid plants will be about $190,000,000.

All of this only opens up new assignments for ion exchange. As prospectors find many new uranium deposits, chemists and engineers learn how to economically process poorer and poorer grades of uranium ores on a fluid basis. The uranium rush will soon be back on a strictly competitive basis in this country and in other parts of the free world and the days of a fixed price for uranium are numbered. A big question for the future to decide is who can produce uranium with the lowest overall costs. The odds are in favor of those who do the job on a fluid basis with the least amount of total manual labor. Eventually at some future time when much more selective ion exchangers are finally developed, the field will come to full flower. Eventually we may extract the rare earths from sea water or develop new kinds of mining in which only the solvent solutions instead of men will go underground. The ion exchange trunk line of science has never ending possibilities for the future.

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U. S. Uranium Production

Speaking on June 25 at a Conference on Uranium and the Atomic Industry cosponsored by the Atomic Industrial Forum, Inc., and the Denver Research Institute, Jesse C. Johnson of the U. S. Atomic Energy Commission discussed uranium production in terms of requirements for military and civilian programs. He pointed out that uranium ores now mined in the Colorado plateau are now well above the average grade that can be obtained elsewhere in the world. In 1948 approximately 70,000 tons of uranium ore were mined in the United States. Today ore production is at a rate of nearly 3,000,000 tons per year and is expected to reach five or six million tons.

At present the United States is the Free World's leading uranium producer, according to Mr. Johnson. Even with expansion programs now under way in Canada and South Africa, domestic production during the next five years will provide the major portion.

Cri de Coeur or

The Problems of a Soviet Chief Designer

The following article is a report of an interview—following an industrial conference—with chief designer L. A. Shubenko, of the Kharkov Turbine Works, which appeared in the Soviet publication *Novy Mir* (No. 7, page 33, 1955). The report is in many ways revealing and a slightly abridged version as presented in the English magazine, *Engineering* Vol. 180, No. 4692, Dec. 30, 1955, is given here by special permission of that publication without comment.

IN SUMMARIZING the discussion at the industrial conference it is necessary to ask: why is there a gap between the new and growing level of technology and the level of work of the backroom boys and the administrators? In fact, why are the backroom boys dragging along in the rear? The first cause is the narrow scope of designing and research work, and of our experimental shops. The second is the lack of creative friendly competition, and the monopoly position of many groups of designers; and the third is organizational trouble. However hard it is to recognize our faults, we must do so, or everything will stop as it was before.

We live in an age of immense developments in science and technology—the atomic age. Every day we hear of new dramatic achievements in human thought. In this state of affairs the time factor is of paramount importance. If you stop for a single day, you fall behind. What has happened is that our scientific and technical inventiveness has been used up on meeting the most urgent needs of production, and has given little thought to tomorrow; it has been unable to prepare for future technical advance. At first, this lag was imperceptible (it may have been concealed from us by our self-satisfied outlook), but now it has begun to hinder our rapid technological development. Consequently, some of our machines, which used to be as good as the best foreign designs, are now out of date, worse than, say, the American.

New Cars

We have all seen on our streets a crowd of gaping bystanders surrounding a foreign car of new design. Sooner or later a voice from the crowd annoys us by saying: "We can't make them like that." Is this remark really justified? Are Soviet designers less talented than those of Ford's or General Motors? I'm sure they are not. We can "make them like that"—and we can do even better. As for gaping bystanders—why call them names?—they are more interested in new technology than the wretched managers of industry who should be producing new models of cars.

Soviet engineers cannot be blamed. Our scientists and designers have often shown in practice their ability to produce the most advanced excavators, aircraft, turbines, and other machinery, not to mention our discoveries in atomic science. The talent of scientists and designers is evidently not at fault.

For instance, we have to use aerodynamic estimates for the rotating parts of a turbine which are 20 years old, and even then they were made abroad. If we were able to experiment, we could easily make fresh estimates and raise the efficiency of our present turbines by at least 5 per cent, which would save the country at least 200 million rubles of fuel per annum. If 10 million of the 200 million rubles we spend every year on warming the earth's atmosphere with our power stations were allocated for research, we should save 190 within a year. But the Ministry of Finance is not in the least interested in making 2000 per cent profit.

Monopoly and Competition

The narrow scope of our experimental work also leads to our second fault—the absence of creative friendly competition. The bestial competitive system does not and cannot exist here, but we need to have friendly competition, and we have no one to compete with. We are monopolists in our specialty. The Leningrad Metal Works are monopolists in other turbines. There is no one to criticize us—whatever we do, it is all right. Recently, our Ministry showed some initiative, and ordered three groups of designers to work out the plans for hydroturbines at a new power station—our designers, and those at the Leningrad and Syzran Turbine Works. The group which produced the best preliminary plans would also prepare the final plans and make the turbine. This was a very good start—the three groups sprang to life, each trying to do better than the others. Friendly competition of this kind must be encouraged in every way.

These are what one might call the large problems of large-scale power production. But the large depends on the small. Here are some small things that we have to put up with. Someone had the bright idea of including designers in the administrative staff. Now administrative staffs are being cut throughout the country, so they have cut down the number of designers, who are the most necessary people in production; and of course they have not cut administrative expenditure on telegrams and unnecessary paperwork, but on pencils and drawing paper.

Under-the-Counter Methods

We have to buy them ourselves. Can you imagine a worker buying a drill in a shop? But this is what designers have to do. I remember last year's epic case of ten

sets of Kuhlmann drawing instruments. There is a small factory here in Kharkov which makes them, but it is all arranged so that their director cannot sell them to us, and our director cannot buy them; so the designer is deprived of the simplest instruments he needs.

To get hold of these ten sets, I had to humiliate myself and be crafty, to use what we call blat (under-the-counter methods), to rattle my medals at the regional committee and the director of the other factory. I went from office to office to tie that director down. Finally, he took pity on me; "All right," he said, "I will produce ten sets in excess of the plan and sell them to you." Then I crawled to my own director. "Give me the money for the instruments," I said. A matter of a few thousand rubles would seem unimportant for a works as big as ours, but it turned out that a works director had no power to spend this measly sum without permission from his superiors.

We had to scheme to get it. That great schemer Ostap Bender (the "hero" of Ilf and Petrov's novel of the NEP period, "Diamonds to Sit On") would have envied our cunning. We got the money under the heading "Capital Construction." We bought ten sets of instruments and now we are terrified of the auditors. If things go on like this, I'm afraid that pencils will find their way into "Capital Construction."

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*Steam Purity Determination by Tracer Techniques**

By E. E. COULTER and T. M. CAMPBELL

Babcock & Wilcox Co.

THE gradual improvement in the performance of separating equipment in boiler steam drums has necessitated corresponding improvements in techniques for measuring impurities in steam. Approximately thirty years ago, the most common method of measuring steam quality was the use of a throttling calorimeter. As operating pressures increased to 450 psi and above, the use of the throttling calorimeter became impractical, and the electrical conductivity method, which has been the most commonly used and the most widely accepted method for measuring mechanical carryover in steam for the past 20 yr, was developed.

Although the almost universal use of the electrical conductivity method continues, there are a number of reasons for doubting the accuracy of the method. For example, the level of carryover from several boilers may be in the order of $^1/_2$ ppm, as indicated by the conductivity of condensed steam samples; yet, the fouling that occurs in the turbines supplied by these boilers may vary considerably from a complete absence of turbine deposits to deposits so severe that washing or cleaning is required every few months. Also, variation of boiler load or solids concentration in the boiler water over wide ranges usually fails to have any effect on the conductivity of condensed steam samples. For these reasons many people, including the authors, suspect that the actual carryover level from most boilers is much less than that indicated by the conductivity method and that the significant changes in carryover occur at some low value where the method is inaccurate.

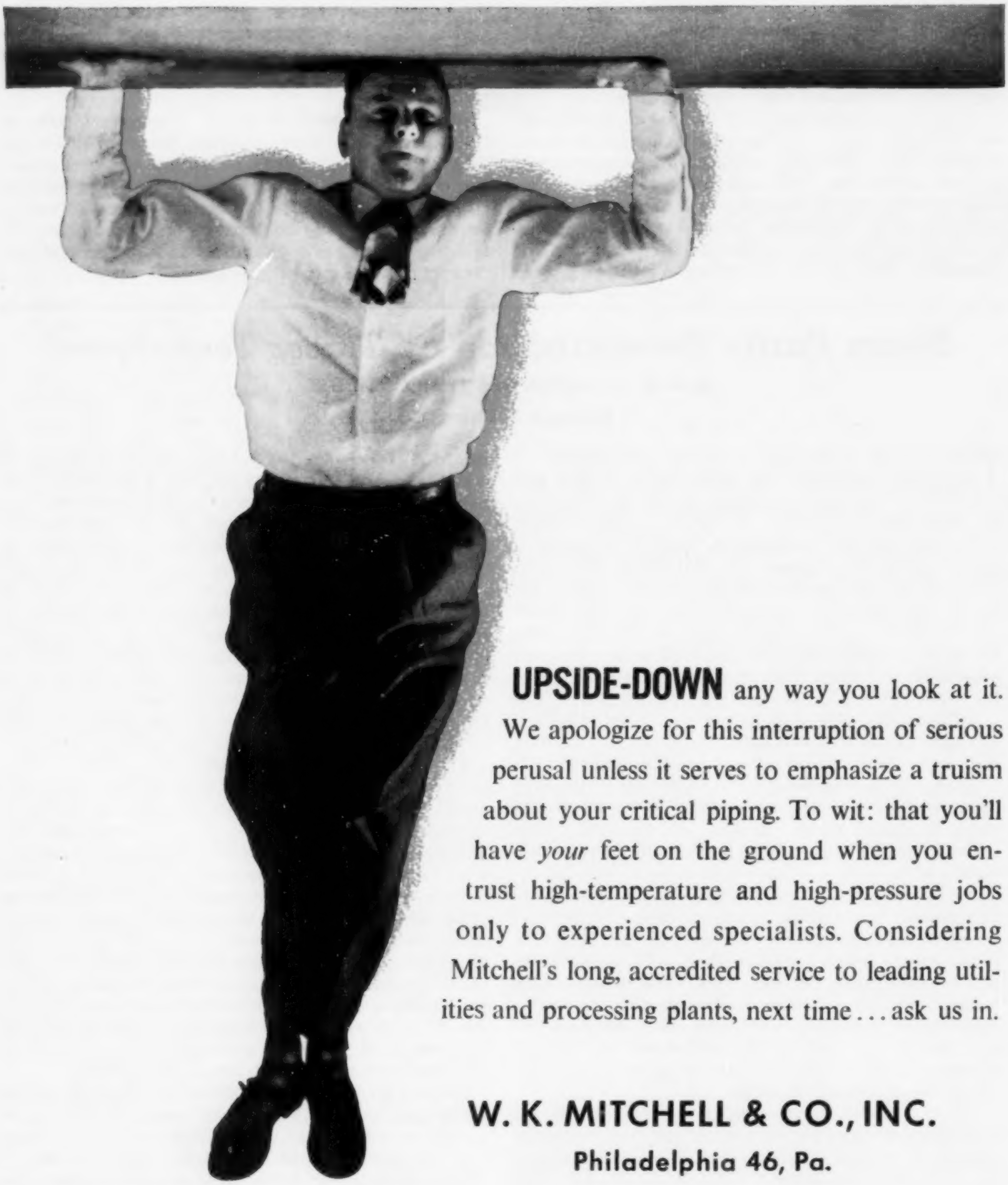
The radioactive tracer technique consists of adding a radioactive material to boiler water and determining the amount of mechanical carryover in the steam by measuring its level of radioactivity. The principal advantages of the radioactive tracer technique are its extreme sensitivity and freedom from contamination errors. The high sensitivity results from the fact that the method consists of counting atoms rather than measuring concentrations of material in the samples. The method is completely unaffected by contamination from sample lines or by dissolved gases in the condensate samples.

The choice of the particular radioactive isotope to be used as a tracer is one of the most important initial decisions to be made. In general, gamma radiation is easier to measure than beta particles, particularly if the radioactive material and the measuring device used are separated by a containing vessel. On the other hand, if appreciable quantities of material giving off gamma radiation were used, it would be necessary to provide shielding to protect personnel in the vicinity of the test from harmful radiation. This consideration limits the choice of tracer materials to beta emitters for most steam purity applications. Since a large fraction of beta particles, even of high energy, are absorbed by as little as $^1/_{16}$-in. of plastic or similar material, a tracer which is a beta emitter must be conveyed outside the test apparatus and brought into close proximity to the radiation pickup.

The half-life of the tracer material is another important consideration. The half-life of the isotope chosen must be long enough to assure sufficient radiation throughout the length of the test. For example, if a material having a half-life of two weeks were chosen and it were desired to operate the test for four weeks, it would be necessary to provide four times the minimum radiation at the beginning of the test to have the minimum amount remaining at the end. However, a short half-life simplifies the problems of apparatus decontamination and tracer disposal after the test has been completed. Also, the specific activity of isotopes having short half-lives is usually high, and less material is required for a given radiation level. This has some influence on the cost of the tracer material, which is also a consideration.

Because the radioactive tracer method does not appear to be practical for field-testing standard boilers, the search for other sensitive, practical methods of carryover measurement was continued. Since the idea of using a single material as a tracer seemed attractive, the normal constituents of boilers waters were considered to determine whether any of them could be used as a tracer. As a result sodium was selected, since it is the major solid constituent of most boiler waters. Also the recent development of a flame photometer attachment with photomultiplier tube for the Beckman model DU spectrophotometer enables the measurement of sodium concentrations in condensed steam samples as low as 0.0002 ppm. This would give a sensitivity almost as great as the radioactive tracer technique and should be adequate for boiler test work.

* Abstracted from a paper of the same title presented before the American Society for Testing Materials, Atlantic City, N. J., June 17-23, 1956.



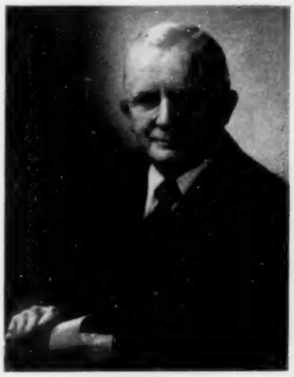
Cleveland Host to ASME Semi-Annual Meeting

FOR the fifth time in its 76 years of activity, The American Society of Mechanical Engineers selected Cleveland as the site for its Semi-Annual Meeting which was held June 18–21 in the Hotel Statler. The usual varied program included papers on such subjects as the ASME interim steam tables,* a supercritical pressure installation at the Avon Plant of Cleveland Electric Illuminating Co.,† a novel arrangement of stacked feedwater heaters,‡ materials handling practice in the Soviet Union, production engineering research in Great Britain, and design criteria for municipal incinerators.

The Calvin W. Rice lecture was presented by **Donald F. Galloway,** research director of the Production Research Association of Great Britain. He reported that the U. S. Government is spending about 100 times as much on university engineering research projects as British industry and government put together; the U. S. (private and government) spent about $5 billion on research and development last year, compared with $700 million for Great Britain; research employs about 500,000 persons here, compared with 60,000 in Great Britain.

At the President's Luncheon **Dr. Joseph W. Barker,** president of the ASME, again emphasized the contribution that individual members of the Society can make in alleviating the engineering shortage in years to come. He urged that members put at the disposal of their local communities the one thing that they can alone give: the priceless advantage of their special training and experience in the engineering profession. This can be done by serving with community organizations and by volunteer work in the local educational system, including taking an active interest in the manner in which children are being taught. Commenting on the millions of man hours that are donated every year for the dual purpose of making ASME more useful to its members and of making the profession of mechanical engineering more useful to the world in which we live, Dr. Barker asked for more cooperation from the membership inasmuch as the benefits are in direct preparation to individual participation in Society activities.

Dr. W. H. Brandt of Westinghouse Electric Corp., one of three men selected by ASME late last year at the request of the State Department to make a tour of Russian manufacturing plants, presented a first hand report on materials handling practice in the Soviet Union. While many Russian factories lag behind comparable American installations in efficiency, Soviet engineers are capable of impressive achievements when they are working on problems big enough to come under the eyes of the planners in Moscow. In estimating the Soviet Union's potential war production, Dr. Brandt concluded as follows: "The advantage is on our side in providing a high standard of living for our people. This advantage is not nearly so marked in producing for war. Everyone must change to a planned economy in producing for war. The Russians know how to operate a planned economy. We must not be complacent about our ability to excel them in military production."



William F. Ryan

The following persons were nominated as officers of the Society for terms beginning during the 1956 Annual Meeting: President, William F. Ryan, vice president and engineering manager, Stone & Webster Engineering Corp., Boston, Mass.; vice president, Region II, William H. Byrne, president, Byrne Associates, Inc., New York, N. Y.; vice president, Region IV, James Sams, Jr., Dean of School of Engineering, Clemson Agricultural College, Clemson, S. C.; vice president, Region VI, Rolland S. Stover, owner of R. S. Stover Co., Marshalltown, Iowa; vice president, Region VIII, Clifford H. Shumaker, chairman, Dept. of Industrial Engineering, Southern Methodist University, Dallas, Texas; directors, Eugene W. Jacobson, Chief Design Engineer, Gulf Research & Development Co., Pittsburgh, Penna.; V. Weaver Smith, vice president, The Lummus Co., New York, N. Y.

Thermodynamics Teaching

Two professors from Princeton University, **William E. Reaser** and **S. L. Soo,** presented a paper entitled "Thermodynamics in Engineering Science." They discussed a combined lecture and laboratory course which is intended to illustrate basic abstract ideas in terms of realistic laboratory demonstrations carried out by the students themselves. The authors described techniques by which the students learn how to measure thermodynamic properties and subsequently to use these properties in a simple analysis of a small power plant. The latter, which may be either on the air or the steam cycle, consists of an oil-fired steam generator, a gas-fired superheater or air heater, a steam or hot air turbine generator, an air compressor and necessary condensers, pumps and piping.

The paper showed some interesting photographs of the laboratory equipment and further expanded the philosophy of this unique combination of thermodynamic theory and engineering practice.

Turbine-Generator Calculations

Another of a series of papers by General Electric engineers on the subject of large steam turbine generator calculations was presented by **H. Hegetschweiler** and **R. L. Bartlett** under the title of "Predicting Performance of Large Steam Turbine-Generator Units for Central Stations." The paper includes more than 30 tables and graphs as well as a worked-out example for the calculation of the principal flow loss quantities for a 250,000-kw cross compound, double-flow reheat turbine generator.

Power Plant Analysis

Prof. W. A. Wilson of Massachusetts Institute of Technology presented a paper entitled "An Analytic Procedure for Optimizing the Selection of Power Plant Components" in which he attempted to devise analytical techniques which may limit the amount of "cut and try" steps followed in the selection of power plant components. The economic problem of optimization is to minimize the total cost of performing a given task

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* "Properties of Steam at High Pressures—An Interim Table" by R. C. Spencer, C. A. Meyer and R. D. Baird, COMBUSTION, June 1956, Vol. 27, No. 12, pp. 57–60.

† "Avon No. 8—A Supercritical Pressure Unit" by C. A. Dauber, Cleveland Electric Illuminating Co. To be published in COMBUSTION, August '56.

‡ "A New Way to Simplify the Steam Power Plant" by H. A. Kuljian and W. J. Fadden, Jr., which appears on pages 51–55 of this issue of COMBUSTION.

where that cost is the sum of two parts: (1) operating costs, and (2) fixed charges. In the case of a power plant the former are closely related to the heat rate and the latter to the total capital investment. In general, the heat rate can be improved by increasing investment.

In making the analysis Professor Wilson divided the functions of a power plant as follows:

(1) Components, such as coal handling equipment, which do not influence the power output and can be chosen independently of the rest of the plant.

(2) Components, such as circulating water system and the condenser proper, which cooperate with each other to produce a single common effect which their influence is felt on the rest of the plant.

(3) Components in which the costs are determined solely by the selection of the cycle and the plant rating.

(4) Components, such as the turbine exhaust annulus and feedwater heaters, which are subject to modification in finite steps.

Municipal Incinerators

Based on his experience over the past 50 years in designing municipal incinerators, **S. A. Greeley** of Greeley and Hansen, Chicago consulting engineers, concluded that problems encountered in this area are as difficult as any in sanitary and municipal engineering. He pointed out that three types of designers may be involved in refuse incineration practice; the designer in a public works office, the designer in private consulting practice, and the proprietary designer associated with manufacturers.

Among the factors that may be considered are the types of furnaces and burning rates, the degree of air pollution control and necessary equipment, draft facilities and architectural treatment of the refuse incinerator building. The author presented a number of tables giving specific numerical values for some of the principal design criteria.

A second paper on municipal incinerator design was presented by **Abraham Michaels,** chief of refuse disposal and plant operations, City of Philadelphia. First of all, the quantity of material to be disposed of must be known. Next the refuse collection practice of the municipality must be known, since this will determine the types of material, specific weights, moisture content and preparation of organic, combustible and noncombustible materials to be handled. Another consideration is the plant site and its location both with respect to the center of collection and to residential areas which may affect the design to minimize air pollution. Still another fact to be considered is the degree of mechanization and automatic control desired by the municipality. Mr. Michaels then described several current installations and presented an extensive tabulation, shown in the accompanying table, which was originally prepared by W. A. Xanten, superintendent of Sanitation, Washington, D. C.

Metallurgical Research

Three engineers from the Alle-

TYPICAL INCINERATOR

	City	State	Plant Designation	Capacity 24 Tons per Hour	Year Completed	Material Burned	Incinerator Manufacturer	Type of Grate	No. of Furnaces	Capacity of Each Furnace	Combustion Chamber Total	Type of Dust Collection System
1	Atlanta	Ga.	City of Atlanta incinerator	700	1950	Refuse[a]	International Incinerators, Inc.	Rotary kiln reciprocating grate	4	175	4	Settlement
2	Baltimore	Md.	No. 4 incinerator	800	1955	Refuse	Pittsburgh-Des Moines Steel Co.	Flynn & Emerich hydraulic stoker	4	200	4	Baffle & checker wall
3	Brookline	Mass.	Brookline incinerator	300	1952	Refuse	Nichols Engineering and Research Corp.	Monohearth	2	150	2	Baffles & screens
4	Buffalo	N. Y.	Westside incinerator	400	1953	Garbage	Nichols Engineering and Research Corp.	Cast iron	3	133	3	Baffles & screens
5	Cincinnati	Ohio	Westfork incinerator	500	1954	Refuse	Nichols Engineering and Research Corp.	Monohearth	4	125	4	Expansion chamber
6	Cleveland	Ohio	....	900	1935	Refuse	The C. O. Bartlett and Snow Co.	Flynn & Emerich[b] hydraulic stoker	6	150	.	Expansion chamber
7	Fort Worth	Tex.	Valley View	250	1953	Refuse	Morse-Boulger Destructor Co.	Tilted	2	125	1	Settlement
8	Hartford	Conn.	North Meadows Municipal	600	1954	Refuse	Morse-Boulger Destructor Co.	Circular, manual dump	4	150	4	Expansion chamber
9	Jacksonville	Fla.	Margaret St. & McCoy Blvd.	300	1952	Refuse	Nichols Engineering and Research Corp.	Cast iron	2	150	2	Settlement
10	Los Angeles	Cal.	Gaffey St.	100	1954	Rubbish	Morse-Boulger Destructor Co.	Morbo-Stoker	1	100	1	Settlement
11	Los Angeles	Cal.	Lacy St.	400	1955	Rubbish	F. O. De Carie	Suspended water cooled	2	200	2	Water spray
12	Miami	Fla.	20th St. incinerator	900	1955	Refuse	Nichols Engineering and Research Corp.	Monohearth	6	150	6	Water spray
13	Milwaukee	Wis.	Lincoln Ave. plant	300	1955	Refuse	Pittsburgh-Des Moines Steel Co.	Flynn & Emerich inclined	2	150	2	Water spray
14	Milwaukee	Wis.	Green Bay Ave. plant	300	1954	Refuse	Nichols Engineering and Research Corp.	Monohearth	2	150	2	Water spray & baffles
15	Minneapolis	Minn.	South Side incinerator	300	1939	Garbage	....	Shaker type finger and dump grate	3	100	3	Settlement
16	New Orleans	La.	Incinerator B	200	1929	Refuse	The C. O. Bartlett and Snow Co.	Stationary bars	2	100	2	Settlement
17	New Orleans	La.	Incinerator C	200	1929	Refuse	The C. O. Bartlett and Snow Co.	Stationary bars	2	100	2	Settlement
18	New York City	N. Y.	South Side incinerator	1000	1954	Refuse	....	Traveling grate[e]	4	250	4	Expansion chamber
19	Norfolk	Va.	....	400	1945	Garbage	Nye Odorless Incinerator Co.	Cast iron Herringbone	4	100	4	Settlement
20	Philadelphia	Pa.	Southeast	300	1951	Rubbish	Nichols Engineering and Research Corp.	Monohearth	3	100	3	Settlement
21	Rochester	N. Y.	West Side	450	1955	Refuse	Nichols Engineering and Research Corp.	Monohearth	3	150	3	Water sprays & baffles
22	Rochester	N. Y.	East Side	600	1956	Refuse	Nichols Engineering and Research Corp.	Monohearth	4	150	4	Water sprays & baffles
23	Toronto	Ont.	Commissioners street plant	900	1955	Refuse	Nichols Engineering and Research Corp.	Monohearth	6	150	6	Settlement & baffles
24	Washington	D. C.	Mt. Olivet incinerator	500	1955	Rubbish	....	Flynn & Emerich inclined hydraulic	4	125	4	Expansion chamber
25	Winnipeg	Man.	....	400	1948	Refuse	Nichols Engineering and Research Corp.	Monohearth	4	100	4	Settlement

[a] Mixed refuse. [b] Converted 1955. [c] Hours per week. [d] Cost of both plants. [e] Combustion Eng'g. Co.

gheny Ludlum Steel Corp., **R. A. Lula, A. J. Lena,** and **H. M. Johnson,** presented a paper entitled "Effect of Cold Work on Elevated Temperature Properties of Types 301, 305 and 310 Stainless Steels."

They offered the following summary and conclusions:

(1) Cold-working increases the rupture strength of Types 301, 305 and 310 stainless steel, providing the degree of cold work and conditions of exposure are not conducive to extensive recrystallization.

(2) The increase in strength derived from cold-working is greater in magnitude, the lower the testing temperature.

(3) The optimum amount of cold work for beneficiation is dependent upon testing temperature and time and decreases with increasing time at a given temperature or with increasing temperature at a given time.

(4) The beneficial effect of cold-working on high-temperature strength persists through the recovery period prior to recrystallization.

(5) Recrystallization results in a substantial decrease in high-temperature strength of cold-worked austenitic stainless steels. The improvement in rupture strength obtained by cold-rolling is gradually lost with increasing amounts of recrystallization and the stress-rupture values of cold-rolled materials drops below that of the annealed values with more than 50–60 per cent recrystallization.

(6) The decrease in rupture strength due to recrystallization is due to structural modifications which occur as a result of recrystallization. These modifications include changes in grain size and carbide distribution in Types 301, 305 and 310 as well as the accelerated formation of sigma in Types 310.

(7) Martensite produced by cold-rolling in unstable austenitic stainless steels such as Type 301 transforms to austenite at testing temperatures and cannot contribute to high-temperature strengthening.

Piping Stress

E. C. Rodabaugh and **H. H. George** of Tube Turns, Inc., presented a paper entitled "Effect of Internal Pressure on the Flexibility and Stress Intensification Factors of Curved Pipe or Welding Elbows."

The flexibility and stress-intensification factors presently applied in piping flexibility analysis to account for the behavior of curved pipe in bending have been derived from theories and tests with no internal pressure. Pressure tends to reduce the effect of these factors but in smaller and relatively thick-wall piping, commonly used in the past, the effect is of a low order and may be neglected; in larger diameter relatively thin-wall piping the effect is pronounced.

Using strain-energy methods, the paper develops a theory establishing the flexibility and stresses due to in-plane and out-of-plane bending including the effect of internal pressure, and includes results of carefully conducted tests. In a final step, the complex theoretical formulas are reduced to a simple and readily usable approximation.

Liquid Metals

"Orifice-Metering Coefficients and

CONSTRUCTION COSTS

Cranes			Bins Capacity		Bins Dimensions			Stacks			Type of Wall Construction: Furnace		Chamber		Flue		Waste Heat Utilization					Plant Operation		Cost of Plant (in $1000 units)			Consulting Engineers	
Number	Capacity Tons	Capacity Cu Yd	Tons	Cu Yd	Length, Ft.	Width, Ft.	Depth, Ft.	Number	Height, Ft.	Diameter, Ft.	Solid	Suspended	Solid	Suspended	Solid	Suspended	Power Generation	Number of Boilers	Horsepower	Pressure, Psi	Steam, Pounds per Hour	Hours Per Day	Days per Week	Incinerator	Building	Total		
3	3.5	2	500	..	..	..	..	2	..	8	x	..	x	..	Steel		No	4	..	175	32,000	24	7	..	..	1850	Robert and Company Associates	1
3	3.4	..	1000	4000	..	..	..	2	150	12	x	..	x	..	x	..	No	None	..	..	..	24	6	695	1498	2153	Whitman, Requardt & Associates	2
1	4	..	..	..	55	21	..	1	170	10.5	x	..	x	..	x	..	No	None	..	..	..	8	5	204	657	861	Metcalf & Eddy	3
3	3.5	..	..	1210	99	20	16.5	1	185	12.5	..	x	x	..	x	..	No	None	..	..	..	16	5	500	1000	1500	Greeley & Hansen	4
2	3	..	..	1830	110	22	20.4	2	175	10	x	..	x	..	x	..	No	None	..	..	..	24	5	514	980	1494	W. D. Ehlers	5
3	3.5	..	..	9000	..	..	..	3	175	..	..	..	..	..	..	..	No	None	..	..	..	24	7	..	..	875	John Heffelfinger, City Engineer	6
1	..	1.5	..	..	51	19.67	..	1	125	8.5	x	..	x	..	..	..	No	None	..	..	..	20	6	372	..	..	Wyatt Hedrick	7
2	..	2.5	..	2440	110	24	25	2	180	22.75	x	..	x	..	x	..	No	None	..	..	..	16	..	1070	364	1434	Metcalf & Eddy	8
1	3.5	2	360	..	..	..	..	1	109	..	x	..	x	..	x	..	No	None	..	..	..	80[d]	6	..	..	602	Reynolds, Smith & Hills	9
1	3.5	..	..	1325	..	..	..	1	175	8	..	x	..	x	..	x	No	None	..	..	..	..	..	156	358	514	Greeley & Hansen	10
1	3.5	..	..	2000	..	..	..	1	175	10	x	..	x	..	x	..	No	None	..	..	..	..	..	400	300	700	None	11
2	3.5	2.5	..	3600	..	..	..	2	150	12	x	..	x	..	x	..	Yes	4	..	250	26,000	24	7	..	..	3300	Maurice Connell & Associates	12
1	3.5	2	..	1735	78	24	25	1	175	10	x	..	x	..	x	..	No	2	200	..	..	8	5	244	743	987	Department of Public Works	13
1	3.5	2	..	1200	75.5	24	18	1	175	10	x	..	x	..	x	..	No	2	150	..	..	16	5	249	676	925	Department of Public Works	14
1	..	2.5	..	..	80.9	..	21.13	1	180	8	..	x	..	..	x	..	No	None	..	..	..	16	5	..	..	275	City Engineer Department	15
2	2.5	..	..	933	60	35	12	2	125	5.5	x	..	x	..	x	..	No	None	..	..	..	14	6	300[d]	230[d]	530[d]	Staff Employees	16
2	2.5	..	None	..	..	..	..	2	125	5.5	x	..	x	..	x	..	No	None	..	..	..	20	6	See note below			Staff Employees	17
2	5	3	550	2800	..	..	..	2	200	11	..	x	..	x	..	x	No	1	..	High	..	24	6	2460	2350	4810	Department of Public Works	18
None	..	..	None	..	..	..	..	2	100	..	x	..	x	..	x	..	No	None	..	..	..	9	6	..	..	275	None	19
1	3.5	2.5	..	3000	..	..	..	1	166	11	x	..	x	..	x	..	No	None	..	..	..	24	$5^{2}/_{3}$	..	..	1330	Day and Zimmerman	20
1	5	3	..	2200	81	24	30	1	165	13	..	x	..	x	..	x	No	None	..	..	..	16	6	460	940	1400	Nussbaumer, Clarke & Velzey, Inc.	21
2	5	3	..	2200	81	24	30	2	204	13	..	x	..	x	..	x	No	None	..	..	..	16	6	640	1470	2110	Nussbaumer, Clarke & Velzey, Inc.	22
3	3.5	..	600	2230	131	20	23	3	175	..	x	..	x	..	x	..	No	None	..	..	..	16	5	880	1015	1895	....	23
3	3	2	325	2700	172	20.83	20.25	2	166	11	..	x	..	x	..	x	No	None	..	..	..	24	5	..	..	1971	None	24
	3.5	..	..	1170	73	24	18	1	175	12.5	x	..	x	..	x	..	No	None	..	..	..	24	5	341	522	863	Greeley & Hansen	25

Pipe Friction Factors for the Turbulent Flow of Lead-Bismuth Eutectic" was the title of a paper by **Prof. H. A. Johnson,** University of California, **Prof. J. P. Hartnett,** University of Minnesota, **W. J. Clabaugh** and **L. Fried,** General Electric Co. The authors described a test apparatus for measuring lead-bismuth flow and pressure drop. Conclusions from these tests were that pipe-friction factors for the turbulent flow of lead-bismuth eutectic agree with those for the flow of water when compared on the usual dimensionless basis. However, a relatively large unexplainable spread occurs in the results for lead-bismuth eutectic which requires further exploration.

When compared at the same orifice Reynolds number and for the same pipe size, the flow coefficients for lead-bismuth eutectic and for water are equivalent for sharp-edged orifices with flange taps.

An experimental heat-transfer program has been under way for some time at the Brookhaven National Laboratory, the general purpose of which is to obtain and correlate heat-transfer coefficients for liquid metals flowing outside of tube banks. A paper entitled "Heat Transfer Rates to Cross Flowing Mercury in a Staggered Tube Bank" by **R. J. Hoe,** Knolls Atomic Power Laboratory, **D. Dropkin,** Cornell University, and **O. E. Dwyer,** Brookhaven National Laboratory, offered the following conclusions regarding the cross flow of mercury in a staggered tube bank:

(1) The local heat-transfer coefficient varies smoothly from a maximum at the forward stagnation point to a minimum at the rear stagnation point in the Reynolds-number range 15,000–80,000, the magnitude of the variation corresponding to a factor of 4–5.

(2) The average heat-transfer coefficient for a tube in the interior of the bank varies as the 0.52 power of the velocity for nonwetted tubes and 0.66 for wetted tubes.

(3) For tubes located in the interior of the bank, wetted tubes give heat-transfer coefficients considerably greater than those for unwetted tubes, e.g., at a Reynolds number of 5×10^4 they are 35 per cent greater. For a tube located in the front row, the difference was found to be much greater, the corresponding figure being 65 per cent.

(4) The lower coefficients obtained in the front row of the tube bank compared to those in the interior, for the nonwetted tubes, is in general agreement with results obtained with ordinary fluids.

(5) Tubes located at the side walls give coefficients about 20 per cent below those for tubes located in the interior of the tube bank.

C. F. Lucks and **H. W. Deem** of Battelle Memorial Institute presented a paper entitled "Apparatus for Measuring the Thermal Conductivity of Liquids at Elevated Temperatures: Thermal conductivity of Fused NaOH to 600 C." Thermal conductivities of liquids at elevated temperatures are measured using the steady-heat-flow method. Heat introduced into the specimen flows downward through a series-connected, Armco-iron heat-flow meter into a water-cooled sink. The quantity of heat flowing at steady-heat-flow condition is measured from temperature gradients in the heat-flow meter. Guard cylinders, auxiliary heat controls, and insulation minimize lateral heat flow. A hydrogen atmosphere protects the specimen. The method used for determining thermal conductivities gives true values for the liquid itself, eliminating the effect of liquid-solid interfaces and other fixed thermal resistances. Two or more heat-flow equilibria conditions are ob-

tained at different specimen thicknesses, but at the same mean specimen temperature. The measured values of the thermal conductivity of fused sodium hydroxide are found to vary linearly with temperature, and at 400 and 600 C are 0.0022 and 0.0026 cal per sec per sq cm per deg C per cm, respectively.

Combustion of Fluid Coke

At a session on Combustion of Fluid Coke sponsored jointly by the Fuels and Power Divisions, D. S. Frank of Pure Oil Co. paid tribute to **Ollison Craig,** vice president of the Riley Stoker Corp., who passed away early in April of this year. Mr. Craig was widely known for his activities in fuel burning research and equipment development since the early days of pulverized coal firing in the 1920's. He had been extremely active in the work of the Fuels Division of the Society and was a co-author with **Harry H. Smith** of a paper presented at the Cleveland meeting on the subject of "Burning Fluid Coke." The authors described the fluid coking process as developed by Esso Research and Engineering Co. and provided typical physical and mechanical properties of fluid coke. They also made comparison of combustion properties with coke breeze and with delayed coke. Tests were conducted at the South Charleston, West Virginia, plant of Carbide and Carbon Chemicals Corp. on a 289,000 lb per hr steam generating unit. On the basis of these tests the following conclusions were drawn:

(1) A different furnace design to that used for anthracite is desirable because of the minute quantity of ash.

(2) Efficiency of burning is enhanced by a high primary air temperature.

(3) Burner design must permit fast heating of the coke particles by the radiant heat from the flame.

(4) Reinjection from the dust collector is practical and results in an increase in efficiency.

(5) Opposed firing inclined downward produces a very stable flame with little or no auxiliary fuel.

(6) Opposed firing inclined downward is effective in burning fluid coke with low excess air and very low carbon loss.

"Multi-Fuel Firing of Cyclone Furnaces" by G. A. Watts and W. L. Sage, The Babcock & Wilcox Co., was the title of the second paper at the session on combustion of fluid coke. Following a description of the principles of operation and the essential fuel requirements for cyclone firing, the authors described tests that were conducted at the B & W Research Center on a number of fuels. These included lignite, natural gas, fuel oil, wood waste, fluid coke, petroleum pitch and coal chars. They discussed some of the problems of burning these fuels individually or in combination and provided information on a unit to burn coal char at a capacity of 1,500,000 lb of steam per hour.

Discussion

There was considerable discussion of the two papers on burning of fluid coke. Questions were raised as to the protection of inside of cyclones when burning oil or gas, and as to the possibility of glazing the water-walls of the outer furnace when cyclone firing. In both cases the authors advised that these were not serious problems. Mention was made that petroleum coke has a very small quantity of ash and tends to clean off furnace tubes to a degree greater than desirable unless there is supplementary firing of a fuel with higher ash content. In one California plant, full boiler rating has been obtained using a type of delayed coke with less than 10 per cent supplementary fuel. Opinion was expressed that it may be feasible for plants now burning oil and gas to add pulverizing equipment to burn as much as 50 per cent fluid coke in the same unit.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Problems and Control of Air Pollution

Edited by F. S. Mallette

Reinhold Publishing Corp., 272 pages, $7.50

As a part of its Seventy-Fifth Anniversary celebration, The American Society of Mechanical Engineers sponsored the First International Congress on Air Pollution which was held in New York City on March 1–2, 1955. This book, which was edited by the secretary of the ASME Committee on Air Pollution Controls, contains the complete texts of the papers presented at the Congress.

Sessions at the meeting were devoted to gaps in available knowledge on air pollution, current developments, treatment and recovery of sulfur dioxide, and air pollution experience outside of the United States. There were two papers on the removal and recovery of sulfur dioxide from central station stacks, one by R. L. Rees of the Central Electricity Authority of Great Britain and the other by L. B. Hein, A. B. Phillips and R. D. Young of the Tennessee Valley Authority. Among other subjects covered were meterological problems in air pollution control, exhaust gases from diesel engines, incinerator designs and health aspects.

Fifth Symposium (International) on Combustion

Reinhold Publishing Corp., 802 pages, $15.00

At the Fifth International Combustion Symposium held at the University of Pittsburgh in 1954, 101 papers by 182 contributors were presented. Emphasis was placed on the chemical aspects of combustion, especially combustion kinetics. Papers were presented on the following subjects: combustion of fuel droplets, propellant burning, combustion of solids, diffusion flames and carbon formation, combustion of engines, kinetics of combustion reactions, flame spectra and dissociation energies, heterogeneous burning and theoretical status of the kinetics of combustion reactions.

Among the papers is one by Kenjiro Saji of the Nihon Cement Co., Tokyo, on the combustion rate of pulverized coal in a jet stream. The theory, which is applicable to combustion of pulverized coal in gas turbines or cement rotary kilns, takes into account surface area of particles; surface gas and ash films; type of coal; particle size distribution; turbulent diffusion and scale effects; and the superposition of solid and gas combustion. This paper, as do most of the others, requires the reader to have a more extensive knowledge of the theory of combustion than is commonly acquired by most engineers in the steam power field. It is definitely a book for the combustion specialist, who will find the material extremely well edited by the Standing Committee on Combustion Symposia of the Combustion Institute.

Compilation of Chemical Compositions and Rupture Strengths of Super-Strength Alloys

ASTM Special Technical Publication No. 170, 8 pages, $0.75

Prepared by a task group of Subcommittee XII on Specifications for High-Temperature Super-Strength Alloys of ASTM Committee A - 10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, this list was to include "all super-strength alloys known to or used by the various industries, giving chemical compositions and available properties." Because mechanical properties mean little without the details of processing and heat treatment, only the 100- and 1000-hour rupture strengths have been given and these only to give an indication of the relative high-temperature strengths of the various alloys. Since most of the alloys listed are of a proprietary nature, the probable patentee has been listed.

The tabulated data in this compilation have been gathered from all pos-

sible sources. The chemical compositions are based for the most part on the mid-point of the specification range and are indicated in the tables as "nominal." The creep and rupture data are not recommended for design purposes but are intended to give an idea of the relative strength of the various alloys. The alloy producers will be glad to supply the latest processing and heat treatment information as well as physical properties and other technical data for their alloys.

ASTM Standards on Light Metals and Alloys, Cast and Wrought

ASTM, 276 pages, $3.50

This third edition of "ASTM Standards on Light Metals and Alloys, Cast and Wrought" sponsored by Committee B-7 on Light Metals and Alloys includes not only those specifications and methods of test which come under the jurisdiction of Committee B-7, but also those for light metal alloy die castings prepared by Committee B-6 on Die Castings, and those for aluminum wire and cable for electrical purposes sponsored by Committee B-1 on Wires for Electrical Conductors. Several methods under the jurisdiction of Committee E-1 on Methods of Testing and Committee E-3 on Chemical Analysis of Metals as well as specifications for aluminum and aluminum alloy arc-welding electrodes and for brazing filler metal under the jurisdiction of the AWS-ASTM Joint Committee on Filler Metal have been included to round out the compilation.

The standards include ingots, castings, bars, rods, wire, forgings, pipe and tube, sheet and plate, wrought products for electrical purposes filler metal, electroplating, and general methods of test. There is also included the ASTM codification system for light metals and alloys.

Bibliography and Index on Dynamic Pressure Measurement

By W. G. Brombacher and T. W. Lashof

U. S. Government Printing Office, 124 pages, $0.75

National Bureau of Standards Circular 558 contains a bibliography of 850 items on dynamic pressure measurement and, in less detail, on related subjects such as static pressure measurement and general information on the components of instruments. The references have been extensively indexed and classified by subject and author to assist the

user in the task of making detailed analyses with respect to his particular interest. The bibliography may also serve as the starting point for more detailed surveys of more specialized parts of the subject.

Dynamic pressure measurements are important in many fields of science and industry, for example, wind tunnel research on explosives and propellants and internal combustion engines.

The publication was prepared as part of a cooperative program of development and research in basic instrumentation sponsored by the Office of Naval Research, Office of Scientific Research of the Air Research and Development Command and the Atomic Energy Commission.

Tables of Thermal Properties of Gases

By Joseph Hilsenrath, et al.

U. S. Government Printing Office, 448 pages, $3.75

National Bureau of Standards Circular 564 comprises tables of thermodynamic and transport properties of air, argon, carbon dioxide, carbon monoxide, hydrogen, nitrogen, oxygen and steam. Co-authors include Joseph Hilsenrath, C. W. Beckett, W. S. Benedict, L. Fano, H. J. Hoge, J. F. Masi, R. L. Nuttall, Y. S. Touloukian and H. W. Woolley. Compressibility factors, density, entropy, enthalpy, specific heat, specific heat ratio and sound velocity are tabulated for real gases at pressures up to 100 atmospheres and to temperatures of 600 F for hydrogen, 1500 K for carbon dioxide, 850 K (1070 F) for steam and 3000 K for the remainder. The ideal gas thermodynamic functions are tabulated uniformly to 5000 K. Also tabulated are the vapor pressures and transport properties, including thermal conductivity, viscosity and Prandtl number. Comparisons are provided to show the deviations of the tabulated values from existing experimental data.

America's Resources of Specialized Talent

By Dael Wolfle

Harper & Brothers, 332 pages, $4.00

In the face of the rising public interest and concern with the supply of scientists and engineers, this book offers considerable background material and statistical information. Subtitled "A Current Appraisal and a Look Ahead," it is the report of the Commission on Human Resources and Advanced Training which began work in surveying the requirements for specialized manpower as far back as 1949.

The author, who acted as director of the Commission studies, considers educational manpower as a national resource which must be developed, conserved and used to its greatest advantage. Countering the argument that an "intellectual elite" may be the outcome of too great emphasis on specialized intellectual talent, he offers the following concepts:

"The democratic ideal is one of equal opportunity; within that ideal it is both individually advantageous and socially desirable for each person to make the best possible use of his talents. But equal opportunity does not mean equal accomplishment or identical use. Some men have greater ability than others and can accomplish things which are beyond the powers of men of lesser endowment. Along with moral and legal and political equality goes respect for the proper use of excellence. . . .

"The nation needs to make effective use of its intellectual resources. . . . Democracy at its best gives each child access to the education and opportunities which will enable him to develop his potentialities. . . . What the specialists have in common is trained intelligence. The scientists and ministers the doctors and philosophers, the engineers and management experts, and all the other specialists who work at comparable levels possess the ability to use their heads, the capacity for abstract thought which takes them beyond the self-evident. . . . The state of the world for some centuries to come may hinge largely upon the effectiveness with which the United States employs her intellectual resources."

These words were written in 1953 and 1954 at a time when there was less widespread concern than at present with the relative numbers of scientists and engineers being trained on either side of the Iron Curtain. They introduce a series of chapters which examine trends in the number and specialty of college graduates, the occupational distribution of college graduates, variations in supply and demand by specialized fields, future supply of specialists, intellectual characteristics of students entering specialized fields, how well graduates are utilized and how this use may be improved.

The book contains a great deal of statistical information showing the distribution of students by specialized fields, over a period of fifty years, together with their intellectual qualifications as measured by test scores. To those who are concerned with the prospects for winning the world competitive race in technology, this book should prove of considerable interest.

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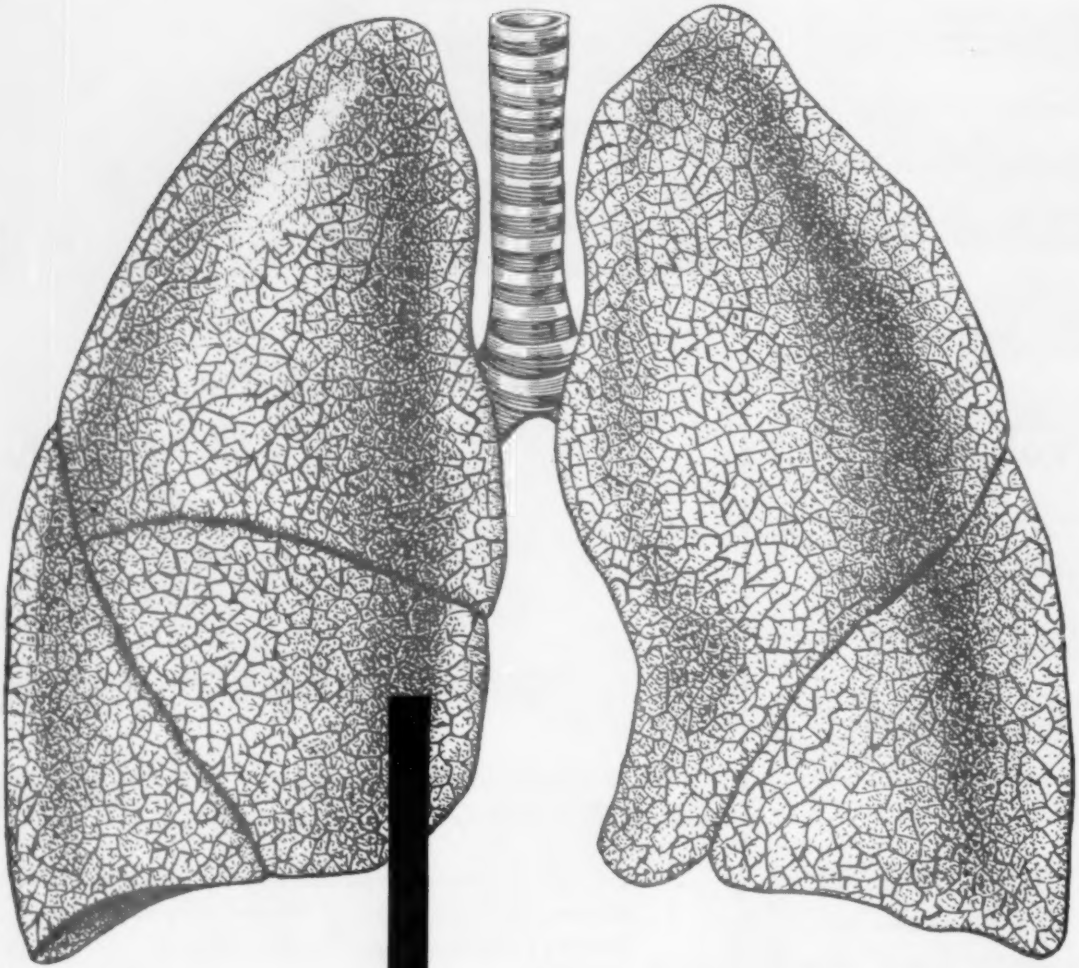

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